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SCIENCE, NATURAL AND SOCIAL

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SCIENCE, in the more restricted sense in which it is normally employed in English-speaking countries, is that activity by which to-day we attain the great bulk of our knowledge of and control over the facts of nature This activity, like other human activities, has developed and evolved, and by no means all the stages in its evolution have merited the title of scientific In remote prehistoric times, our early ancestors worked by trial and error combined with simple, intuitive common sense This prescientific approach, however, was combined with the non-scientific methods of control that we call magic, and equally non-scientific rationalizations in the field of explanation But science in this phase was still, to our modern view, unscientific in two major aspects—it was traditional and it was esoteric Scientific knowledge was confined to a limited group among the priesthood, and it was cast in a mould of tradition which rendered change and progress slow Being associated with the priesthood, it was also intimately bound up with non-scientific practice and non-scientific interpretation—magic and theology.

After some three or four millennia, the Greeks suddenly burst free of the prison of secrecy and traditionalism and proclaimed the freedom of intellectual inquiry The "birth of science" is usually dated from them, but the assumption is only a half-truth At best it was the acquisition of freedom and self-consciousness by the scientific spirit, not the emergence of a wholly new activity to be called science And in the second place, the type of science which it inaugurated differed radically from modern science in several respects It was almost entirely divorced from industry and practical application, it was exceedingly speculative and did not lay the same stress on experimental verification as we do; and, correlated with this, it had not invented the modern methodology of publication of the data and methods used, as well as the conclusions reached

A few centuries later, the combination of Greek intellect and ingenuity with the practical spirit of the Roman imperium made Alexandrian science something much more like modern science in outlook and methods of working But this was swallowed up in the anti-scientific Christian flood and the general collapse of Roman civilization

During the Dark Ages in the west, the Arabs kept the scientific spirit alive, and by means of their mathematical inventions paved the way for immense improvements in the technique of scientific research

Natural science, in its modern form, can fairly be said to date back no further than the seventeenth century. With Bacon as its St. John the Baptist, it developed its gospel and its ministry. Curiosity for its own sake, but also interest in industrial techniques and practical control, freedom of inquiry; experimen-

tal verification in place of authority; full publication and abundant discussion —with these a truly new phase was inaugurated.

To-day it seems that we are again in the process of launching a new phase of science—one in which social as well as natural phenomena are to be made amenable to scientific understanding and rational control.

As with natural science, social science too has had its earlier stages It too passed through the stage of trial and error, in which social organization shaped itself under the influence of unconscious adjustment together with non-rational rules of conduct and non-scientific interpretations of human destiny. It also had its traditional phases, often tightly bound up with philosophical and theological interpretative principles, as, for example, in the climax of the Middle Ages. And it has had its birth of free speculative inquiry, parallel to the Greek phase of natural science—but two thousand years later, in the philosophers of the seventeenth and especially the eighteenth century

Finally, its modern stage now dawning has had, like the modern stage of natural science, its scattered precursors, its Roger Bacons and Leonardos—and it has had its precursor in the restricted sense, its equivalent of Francis Bacon in the Renaissance Many, I am sure, would put Herbert Spencer in this position; but I believe that the true John the Baptist of social science is Karl Marx. Herbert Spencer, for all his academic knowledge—or perhaps because of it, was more in the position of an Old Testament prophet. His work was essentially analogical. He demonstrated that social science was an inevitable development; but his notions of what form it would actually take and what methods it should employ were vague and essentially erroneous.

Marx, on the other hand, developed a system directly based on social facts and directly applicable to them. He did not just prophesy *a* Messiah; he indicated *the* Messiah. As natural scientists tend to undervalue Bacon because he himself did not make discoveries or work out experimental techniques, so social scientists tend to underrate Marx because his system is a dialectical one, ready-made and complete with answer to any problem, not sufficiently empirical and inductive for their scientific taste. But at least Marx, like Bacon, gave expression to a new outlook and a new method of attack, and helped materially to alter the intellectual climate so as to make it propitious for scientific work in his field.

The question immediately poses itself as to why the emergence of social science into large-scale and efficient operation has been so long delayed. The triumphs of natural science both in discovering radically new knowledge and in applying it practically to satisfy human needs have been so spectacular and so fruitful that it would seem natural and obvious to extend the same methods to the field of social phenomena

The answer is a very simple one: the methods are *not* the same The scientific spirit remains unaltered whether it is contemplating a nebula or a baby, a field of wheat or a trades union. But the methodology of social science is inevitably different from that of natural science It is different and must be different for one basic reason—the investigator is inside instead of outside his material. Man can not investigate man by the same methods by which he investigates external nature He can use the methods of natural science to investigate certain aspects of man—the structure and working of his body, for instance, or the mode of his heredity, but that is because these are shared with other organisms and because they are partial aspects which can be readily externalized. But when he starts investigating human motive, his own motives are in-

volved; when he studies human society, he is himself part of a social structure.

What consequences does this basic difference imply? In the first place, man must here be his own guinea-pig. But this is impossible in the strict sense, for he is unable to make fully controlled experiments Even if an absolute despot were to subject a group of people to rigorous experimentation—by depriving them of alcohol, for instance, or by adopting a new form of education—the results would have only a limited application. The smallness of the group, the compulsion involved, the inevitable limitations on the contacts and full social activity of the group, would make it impossible to apply the results directly to an entire normal society, however regimented And the difficulties are of course enormously greater in any free society

A second, more technical difficulty is in a sense a consequence of the first Causation in social science is never simple and single as in physics or biology, but always multiple and complex It is of course true that one-to-one causation is an artificial affair, only to be unearthed by isolating phenomena from their total background None the less, this method is the most powerful weapon in the armory of natural science: it disentangles the chaotic field of influence and reduces it to a series of single causes, each of which can then be given due weight when the isolates are put back into their natural interrelatedness, or when they are deliberately combined into new complexes unknown in nature.

This method of analysis is impossible in social science. Multiple causation here is irreducible. The difficulty is a twofold one. In the first place, the human mind is always looking for single causes for phenomena. The very idea of multiple causation is not only difficult, but definitely antipathetic. And secondly, even when the social scientist has overcome this resistance, extreme practical difficulties remain. Somehow he must disentangle the single causes from the multiple field of which they form an unseparable part. And for this a new technique is necessary.

Next, and in many ways even more important than the first two together, comes the question of bias. Under this head I include anything appertaining to the investigator which may deflect his scientific judgment. It is the equivalent of experimental and observational error in natural science In natural science, there are statistical methods for discounting both sampling error and personal error; the limits of accurate measurement are determined for different types of instrument; the procedure of controlled experimentation has been reduced to a fine art. The procedure of the discounting of error in natural science by these procedures has proved difficult enough. But to discover how to discount bias in social science is proving very much harder.

Then there is the inherent genetic bias imposed by his own temperament. For certain purposes, investigators in social science are their own instruments to a very great extent and in a way unknown in natural science—and the instruments differ in their very construction

Next we have the bias introduced by the peculiar psychological development of human beings. They can only resolve their inevitable conflicts during childhood and adolescence by relegating a great deal to their unconscious, whether by the psychological mechanism of suppression or that of repression. Roughly speaking, the former introduces bias by leaving gaps in a person's knowledge and outlook, whereas in the latter the gaps are accompanied by strong emotional distortions and resistances. The scientific study of sex, for instance, has been much retarded by repressional bias—witness the reception originally given to Havelock Ellis's great work and the extraordinary resistance still offered to Freud's ideas.

Bias of this type has the additional danger that those who make an effort to discount it may readily swing into overcompensation—a bias of opposite sign. The investigator whose youth was tormented by intolerant religion is apt to discount the social importance of religion far too much; the convert to Freudian methods is liable, in discounting his own early sexual repressions, to underestimate the social value of repression in general

Bias has also been encountered in natural science, but only when its findings come up against emotionally held convictions—only, that is, when it has had social entanglements. We may cite the prohibition of anatomical dissection, the proscription of Galileo's findings, the hostility to the Darwinian theory, the Nazi distortion of racial anthropology, the Soviet attack on modern genetics The present course of general anti-scientific feeling, so noticeable during the past decade, has been due in part to a general feeling that scientific findings, by sapping the traditional view of man's place in the universe and in society, are undermining the basis of ordered society

Finally, there comes the most fundamental difference of all Values are deliberately excluded from the purview of natural science · values and all that they connote of motive, emotion, qualitative hierarchy and the rest constitute some of the most important data with which the social scientist must deal But how can science deal with them? Science must aim at quantitative treatment: how can it deal with the irreducible absolutes of quality? Science must be morally neutral and dispassionate. how can the social scientist handle the ethical bases of morality, the motives of passion?

Let us be frank with ourselves. There is a sense in which, because of this qualitative difference between its data and those of natural science, social science can never become fully and vigorously scientific. To understand and describe a system involving values is impossible without some judgment of values, and still more impossible without such value-judgment is the other scientific function, that of control.

However, this is not quite so serious as at first sight appears Even in natural science, regarded as pure knowledge, one value-judgment is implicit—*belief in the value of truth.* And where natural science passes into control, a whole scale of values is involved. The application of natural science is guided by considerations of utility—utility for profit, for war, for food-production, for health, for amusement, for education. The application of science through the instrument of *laissez-faire* economic systems has brought us to a position at which we are being forcibly reminded that these different utilities may conflict.

Thus, rather crudely, we may say that in respect of the problem of values, social science in its aspect of knowledge is faced by the same difficulties as is natural science in its aspect of control The difficulty is thus in a sense an artificial one Its consideration has reminded us that natural science is not such a pure disembodied activity as is often assumed Language is in part responsible for the assumption There is no such thing as natural science *per se* The phrase is a shorthand description of those activities of human beings which are concerned with understanding and controlling their natural environment. And, just as simple one-to-one causation is a fiction, only approximated to in artificially isolated systems, so the emancipation of natural science from considerations of value is a fiction, approximated to by the possibility of temporarily and artificially isolating scientific activity from other human activities.

In regard to multiple causation, we may look forward to an extended use of techniques of mathematical correlation. These have already been developed to a high pitch for dealing with problems of

multiple causation in physical science, and special methods have been worked out by Spearman and his school for dealing with psychological questions. The use of probability methods is also indicated. Here again, these have been developed to a high pitch for use in natural science. Mathematical methods also enter into another technique which is now being rapidly developed in social science, that of the questionnaire, and especially the set of questions asked by the trained interviewer. The questionnaire method is widely used, but the reluctance or inability of large sections of the public to fill its elaborate forms restricts its sphere and impairs its sampling accuracy. The success of the method in this form depends chiefly on two things—the proper framing of the questions and the obtaining of a truly representative sample of the population to answer them.

Some questions do not admit of a significant answer, or any answer at all; others will defeat their own ends by influencing the form of the answer. In any case, the method of questioning a representative sample of a large population can only be applied to a restricted set of problems, though within limitations it may become extremely efficient. In one field, that of the straw ballot, it is developing such uncanny accuracy that it is infringing upon practical politics. Some people are asking whether a properly conducted straw ballot could not be profitably substituted for the trouble and expense of a full election; while others feel that the announcement of a straw vote may itself influence the course of the subsequent election.

The method of mass observation constitutes an attempt to attain objective information on various aspects of public opinion and behavior which elude the method of yes-and-no questioning. Inquiries may concern the reaction of the public to a particular place, like the Zoo or the National Gallery; to a particular event, like the Coronation; to a particular activity, such as smoking or the time of rising; or to a general situation, like that of war. In some cases, composite pictures which could have been obtained in no other way have resulted from the use of this method. But in general its technique, both as regards sampling and questioning, will have to be refined a good deal before it can claim to be scientifically dependable.

Joint work is on the increase in natural science, but here largely because of the quantitative burden of routine procedures in subjects like bio-chemistry or genetics. We may distinguish such work as group work. The term group is here used in the sense of a body of people pooling their different knowledges and skills to cope with qualitatively differentiated problems. Group work in this sense is also to be found when geneticists, ecologists and statisticians make a united attack on some problem of microevolution, or an embryologist and a biochemist combine to study development. But it is far more necessary in social science.

It may be expected that the working out of various techniques made necessary by the nature of the data of social science will have fruitful repercussions in certain fields of natural science, such as evolution and comparative biological study in general, where the present bias in favor of experimental work and specific results is leaving vast bodies of published data awaiting the synthetic treatment which only organized group attack can provide.

I have already mentioned certain substitutes for the controlled experimentation of the natural sciences. But experimentation as a method is not ruled out in social science, though it must take different forms. Regional or group experimentation is the most obvious method. Two regions or groups are chosen which are as similar as possible, and certain measures are introduced in the one, while the other serves as control. The Carlisle

experiment on liquor control in Britain was an early essay in this method, but unfortunately it has been allowed to drag on without any serious attempts to draw theoretical conclusions or to frame practical policies on the basis of its operation The T V A in America is perhaps the largest social experiment ever undertaken, at any rate in a non-totalitarian country. The area involved, however, is so large that strict controls are difficult to find.

As the spirit of scientific planning extends with government, we may expect to see regional experiments tried out in many fields Medical and health services would afford another excellent field The social results of cheap electric power could be made the subject of local experiments much more rigorous than that of the T.V A.

The fact that in social science man is his own guinea-pig has a number of methodological consequences, both for social science research and for its practical applications The social scientist often requires true cooperation from his material in the sense of understanding of the reason for his work and voluntary participation in its course Education as a social experiment can never succeed without properly equipped teachers, specially trained in pedagogy The interview method will give entirely misleading results without interviewers skilled in the technique of their job.

There remains the question of bias. In this there is no ready method to hand. It took generations for natural science to work the technique of discounting experimental and observational error; it will take generations for social science to work out that of discounting the errors due to bias The first step is obviously to make the world aware of the existence of bias and of the need for its discounting Where human affairs are still handled in a pre-scientific spirit, bias is apt to play a very large practical role, especially the bias in favor of one's own group, whether class, religion or race. Such bias produces powerful rationalizations, which are then used to justify policies of the merest self-interest. The enslavement of Negroes was justified on the basis of the scriptural authority for the mental destiny of the sons of Ham; the brutalities of the Nazi persecution of Jews, on the racial superiority of "Aryans." The group bias of the prosperous classes in early nineteenth-century England appeared in astonishing assertions about the inherent inferiority of "the poor", the same bias is evident in certain aspects of the eugenics movement to-day

Another wide-spread and disastrous form of bias arises from psychological conflict and tension Censoriousness in respect of moral taboos, the desire to see the infliction of vindictive punishment, the unconscious reluctance of many parents to see the harsh school discipline under which they suffered replaced by humaner methods, the emotional basis of militarism—all these and many other undesirable determiners of human conduct are the result of bias arising from repression or emotional conflict and the inflicting of lasting distortion on the psyche.

But even in scientific circles bias may play a surprisingly large part A good example was the resistance of the great majority of medical men during the early part of the last war to admitting any cause for breakdown among soldiers save physical shell-shock and malingering. And the uncritical assumption, even among scrupulously careful persons, that differences in intelligence between social classes were genetic and not due to nutrition or other social factors, is another. Again, we have the thesis of anthropologists, like Levy Bruhl, that savage mentality is in some way qualitatively different from and inferior to our own, whereas it is in fact essentially similar, but operating in different material and social conditions.

Voices are still raised proclaiming that social science is a contradiction in terms, that human affairs are not intrinsically amenable to the scientific method. Those who hold this opinion are, I believe, wrong. They are confusing the methods of natural science with scientific method in general Social science differs inevitably from natural science in many important respects, notably in its lesser capacity for isolating problems, and more generally in its lesser degree of isolation from other aspects of human activity and its consequent greater entanglement with problems of value It must therefore work out its own technique and its own methodology, just as natural science had to do after Bacon and the eager amateurs of the seventeenth century had glimpsed natural science as a new form of human activity.

Let us not forget that the working out of this technique and this methodology by natural science took a great deal of time and is indeed still progressing. During the growth of modern science, the amateur has been largely replaced by the professional, university laboratories have been supplemented by governmental and industrial institutions; whole-time research has become a new profession; the team has in many types of work replaced the individual, cooperative group work is beginning, and the large-scale planning of research is in the offing.

Finally, the enormous growth of applied science has had effects of the utmost importance on pure research. It has done so partly by providing new instruments which would otherwise have been unavailable, one need only instance the gifts of the wireless industry not only to pure physics but to such unexpected branches of science as nervous physiology. And partly by suggesting new lines of research, the needs of wireless have again revealed new facts concerning the upper atmosphere, while the study of plant pests and human diseases has brought to light new modes of evolution.

We need have no fear for the future of social science. It too will pass through similar phases from its present infancy. By the time that the profession of social science, pure and applied, includes as many men and women as are now engaged in natural science, it will have solved its major problems, of new methods, and the results it has achieved will have altered the whole intellectual climate. As the barber-surgeon of the Middle Ages has given place to the medical man of to-day, with his elaborate scientific training, so the essentially amateur politician and administrator of to-day will have been replaced by a new type of professional man, with specialized training Life will go on against a background of social science. Society will have begun to develop a brain.

The Biological Analogy

Writers and philosophers have often attempted to illuminate human affairs by means of biological analogies. Shakespeare, in Coriolanus, drew the analogy between the human body and the body politic in Menenius' speech on the body and its members Herbert Spencer's code is shot through with the premise that human biology is but an extension of biology *sensu stricto*, and that, accordingly, biological analogies will in general have validity. Various German philosophers during the latter half of the past century justified war on the basis of the Darwinian conception of the struggle for existence, and the apostles of *laissez-faire* in Britain found support for economic individualism in the same doctrine Socialists, on the other hand, have pointed to the fact of mutual aid in nature, as set forth by Kropotkin. Analogies with the social organization of ants and bees have been used, according to taste and prejudice, to glorify or to attack the doctrines of human collectivism. The Marxist thesis of progress

being achieved through a reconciliation of opposites, only to lead to a new antithesis, which in turn paves the way for a new synthesis, is customarily documented in the works of communist philosophers by examples from biological evolution.

It is interesting to ask ourselves precisely what validity resides in this method of extending biological principles by analogy into human affairs. At the outset, it is clear that analogy, unless applied with the greatest caution, is a dangerous tool This is clear to the modern scientist, but it has not always been so. Indeed, to put too great a burden on the back of analogy is a fundamental temptation of the human mind, and is at the base of the most unscientific practices and beliefs, including almost all magical ritual and much of supernaturalist superstition During the last millennium, moralists, theologians and scholastic philosophers have often regarded analogy, even of the most far-fetched kind, as the equivalent of proof

Has analogy, then, no part to play in scientific thought? Far from it Analogy is in the majority of cases the clue which guides the scientific explorer towards radically new discoveries, the light which serves as first indication of a distant region habitable by thought The analogy with waves in water guided physics to the classical wave-theory of light The analogy with human competition, after playing an important role in Darwinian theory (did not Darwin arrive at the theory of natural selection from his reading of Malthus?) was transferred by Wilhelm Roux to a smaller sphere, the struggle of the parts within the individual

But analogy may very readily mislead. Weismann sought to apply this same analogy of intra-organismal struggle and selection to the units of heredity; but the analogy happens not to hold good The analogy of a stream of particles misled Newton as to the nature of light.

Analogy thus provides clues, but they may easily be false clues; it provides light, but the light may be a will-of-the-wisp. However pretty, however seductive, analogy remains analogy and never constitutes proof. It throws out suggestions, which must be tested before we can speak of demonstration

But if non-scientists often overrate the importance of analogy, scientists themselves tend to be over-cautious and to underrate its potential value Its value is especially great when the analogy is one between closely related subjects The analogy between the evolution of different groups of animals is often surprisingly close, for the simple reason that both the material and the conditions are essentially similar throughout None the less, unpredictable results are not infrequent. The adaptive radiation of the marsupials in Australia was in its broad lines similar to that of the placentals in the rest of the world, but the placentals never developed large jumpers like the kangaroo, and, correspondingly, the marsupials produced no quick runners like horse or antelope, and no freshwater fish-eaters like the otter Again, the parallelism in the social evolution of the quite unrelated ants and termites is truly astonishing, yet the termites have never produced grain-storers or slave-makers, while the ants have no system of second-grade queens in reserve

One further caveat before we pursue the biological analysis of man's social existence Human societies, though indubitably organic, are unlike any animal organism in the mode of their reproduction. Strictly speaking, they do not usually reproduce at all, but merely perpetuate themselves They exhibit no process of fertilization between living gametes, no distinction between mortal body and immortal germ-plasm They continue indefinitely by the aggregate reproduction of their component individuals. In their development, change of structural and functional pattern can

be dissociated from growth in a way impossible to a developing animal, and social heredity operates via cultural transmission, not by the physical transmission of material potencies of development On the other hand, the separation of phylogeny and ontogeny, the development of the race and the development of the individual, which is so evident in higher animals, is blurred in social development to such an extent that the two often coincide

All analogies between the birth, development and death of civilizations or nations and of animal organisms must be very heavily discounted because of the fundamental difference in mode of their reproduction and inheritance

Now, with these facts in mind, let us look at some of the biological analogies that lie near to hand In the first place, there is the analogy between the societies of insects and those of man This, however obvious and however often applied, must be rejected out of hand. The two rest on different bases—those of ants, bees and termites on the fixity of instinct, those of man on the plasticity of intelligence For this reason man can not and will not ever develop specialized castes, with functions predetermined by heredity, nor will human society ever work with the machine-like smoothness of an ant-hill or a termitary Furthermore, we must not expect that in man the altruistic instincts will ever become predominant: as Haldane has demonstrated, this can only occur when neuter castes of workers or soldiers exist. Altruism in man must be fostered by education and given fuller play by appropriate social machinery, it can not be implanted once and for all by heredity

The next analogy to be considered is that between the body of a higher animal and human society. This has taken two main forms. In the one, the analogy is drawn between the main classes of society and the main organ-systems of the body, or, going a little further into detail, between the specialized functions of various agencies of social existence—trade, government, war, education and so forth—and those of particular bodily organs. In the other, which has been attempted only since the discovery of the cell and the rise of the cell-theory, the cell within the body is compared to the individual within society. An extension of this second analogy bridges the gap between it and the first instead of the individual cell, attention is concentrated on the different types of cells and the different resultant tissues of the body; and these, rather than the still more complex organs, each composed of numerous tissues, are compared with the various specialized trades and professions in human society.

In assessing the value and limitations of these analyses, we must begin by recalling the basic difference btween the animal body and human society, namely, the far greater subordination of the parts to the whole in the former This is especially important for the comparison between cells and human individuals The difference here is the same basic one as that between the castes of a social insect society and the specialized aptitudes of human beings, but pushed to a much greater length The cells of the body are irrevocably specialized during early development, and their specialization is far greater than that between even a queen and a soldier termite. Without the aid of embryological study, no one could guess that a nerve-cell, with its long nerve-fiber and its branching dendrites, a sperm, with condensed head and motile tail, and a fat-cell, an inert lump crowded with globules of reserve fat-stores, were all modifications of a single common type Altruism, in the sense of sacrifice of the unit for the good of the whole, has also been carried to a much higher pitch As with drone bees, only one out of many sperms can ever perform its fertilizing function; the ratio is one to many tens of millions, instead

of one to a few hundreds The cells of the outer skin have no other function than to be converted into dead horny plates, constantly shed and as constantly renewed, the red blood-cells lose their nuclei before being capable of exerting their oxygen-carrying function, and have a life much more limited even than that of worker bees Units may even be pooled. The giant nerve-fibers of cuttlefish are the joint product of numerous united nerve-cells; our own striped muscle-fibers are vast super-units, comparable to a permanently united tug of war team.

In terms of biologically higher and lower, there is thus a radical difference between cells and human beings Both are biological individuals which form part of more complex individualities Cells are first-order individuals, bodies second order ones and human societies, like hydroid colonies or bee-hives, third-order ones But whereas the individuality of the body of higher animal, cuttlefish, insect or vertebrate is far more developed than that of its constituent cells, that of a human society is far less so than that of its individual units

This fact, while it makes the analogy between cell and human individual almost worthless, is of great value itself as a biological analogy, since it immediately exposes the fallacy of all social theories, like those of Fascism and National Socialism, which exalt the state above the individual

A book could be written on the subject of analogies between biological organisms and society One with peculiar relevance to-day is the tendency, repeated over and over again in evolution, for types to specialize on the development of brute strength coupled with formidable offensive or defensive weapons, only to be superseded by other types which had concentrated on efficiency of general organization, and especially on the efficiency of the brain The outstanding example is the supersession of the formidable reptiles of the late Mesozoic by the apparently insignificant mammals of the period.

This phenomenon is often somewhat misinterpreted as the replacement of specialized by generalized types. There is an element of truth in this idea, but the fact is often lost sight of that the successful generalized type always owes its success to some improvement in basic organization Such improvements in general organization are specializations, but they are all-round specializations, whereas what are usually called specializations are one-sided. This distinction contains the kernel of what is probably the most important of our biological analogies—the analogy concerning desirable and undesirable directions of change

A detailed analysis of type of evolutionary change shows that some of them can legitimately be called progressive, in the sense that they constitute part of a steady advance on the part of living matter towards a greater control over and independence of its environment. Only a small and steadily diminishing fraction of life participates in progressive change

Each step in progress is constituted by all-round specialization—an improvement in general organization, one-sided specialization always leads into an evolutionary blind alley.

Here I have only space to mention the two types of change which have been most important in the later phases of evolutionary progress One is the development of mechanisms for regulating the internal environment of an animal, and so making it more largely independent of changes in external environment or better able to pass from one type of activity to another. The other is the improvement of the mechanisms for obtaining and utilizing knowledge of the environment, which in its later stages, after the efficiency of sense-organs had reached its limit, has been brought about by improvement in brain mechanism.

The biological analogy to social affairs is obvious. It provides the most abundant justification for the abandonment of *laissez-faire* in favor of social and economic planning: but the planning must be designed to give society an internal environment which shall be both stable in essentials and flexible in detail, and to enable it to undertake the greatest diversity of functions with the least dislocation

The biological analogy from brain evolution is, however, even more illuminating. As animal evolution continued, the avenues of progress were cut off one by one Changes that had been progressive in their time were exploited to the full and reached the limit of their potentialities Mere bulk of body had reached its limit in the dinosaurs during the Mesozoic, some sixty million years ago. Ten or twenty million years later temperature regulation in certain animal forms had been perfected The exploitation of the insectan type of social life by ants was over about twenty-five millions years back, and ants have not evolved since

Similarly, the number of the groups which might share in progressive change steadily narrowed down Groups like the echinoderms were soon eliminated owing to their headlessness, then the great phylum of molluscs, through defects in general organization; then the insects, through their limited size Only the vertebrates remained The cold-blooded forms were eliminated by the biological invention of temperature regulation, the birds, by their over-specialization for flight; the marsupials, by their greatly inferior reproductive mechanism Among the placentals, now sole repositories of potential advance, the majority of lines cut themselves off from progress by one-sided specialization. Only the arboreal primates escaped, since their mode of life left teeth and limbs unspecialized, while demanding greater efficiency in the highest sense of all, vision, and greater correlation between hand and eye. This correlation meant improvement in brain structure, which split over in the form of increased educability and awareness. Finally, all the primate lines but one wandered into blind alleys, becoming over-specialized for tree life Only the one stock which early redescended to the ground and concentrated on all-round adaptability remained potentially progressive—man The human species has now become the only branch of life in which and by which further substantial evolutionary progress can possibly be realized. And it has achieved this enviable, but at the same time intensely responsible, position solely by concentrating on brain as against other organs as its line of specialization

This evolution of brain, as the one inexhaustible or at least unexhausted source of progress, thus demands our closest attention as a biological analogy for social affairs. With some simplification, the process of brain evolution in vertebrates is resolvable into two main steps—first, the addition of two centers of correlation in different parts of the brain, one for the correlation of sensory knowledge, the other for the correlation of action and of course the two centers were united by communicating cables. This is the stage arrived at in fish. The next step was the provision of a further wholly new center of correlation, superimposed on the previous mechanism. This organ of ultimate adjustment and control consists of the cerebral hemispheres, which are wholly unrepresented in the lowest vertebrates Its essential exchange mechanism consists of the cerebral cortex So far as we know, the cortex, in spite of all localizations and functional specializations within it, always acts as a whole, in the sense that its activity can be thought of as a complex field which is altered in its total arrangement by any alteration in any of its parts.

The final step between ape and man is marked by the great enlargement of those areas of the brain which have the least specialized function—the so-called association areas which lie between the regions wherein are localized the reception of relayed sensory information and the emission of executive messages for action. It is this, it seems, which has made possible self-consciousness and true conceptual thought

During the course of this evolution, the cerebral hemispheres increase from zero to a mass which exceeds that of all the rest of the central nervous system taken together, and they become one of the larger organs of the body.

Our brain analogy, however, does illuminate the social problem in an extremely valuable way In the first place, the highest stage of evolution in this respect which has as yet been reached by any society is, by biological standards, extremely primitive. It corresponds with a quite early stage in the development of cerebral hemispheres—perhaps higher than that of a fish, but certainly not beyond that found in reptiles Before humanity can obtain on the collective level that degree of foresight, control and flexibility which on the biological level is at the disposal of human individuals, it must multiply at least ten-fold, perhaps fifty-fold, the proportion of individuals and organizations devoted to obtaining information, to planning, correlation and the flexible control of execution The chief increases are needed in respect of correlation and planning and of social self-consciousness In these respects, wholly new social organs must be evolved, whose nature we can only envisage in the most general terms.

In respect of planning and correlation, we can dimly perceive that some large single central organization must be superposed on the more primitive system of separate government departments and other single-function organizations; and that this, like the cerebral cortex, must be at one and the same time unified and functionally specialized. It will thus contain units concerned with particular social and economic functions, but the bulk of its personnel will be occupied in studying the interrelations between these various functions

As regards social self-consciousness, the course of evolution must be quite different. Newspapers and books, radio, universal education—these and other points of technological and social advance have given us, in primitive form, the mechanisms needed At the moment, however, they are being, in the light of biological analogy, largely misapplied. Education stops dead for most people in early adolescence, and concerns itself mainly with providing specialized techniques, together with a froth of obsolescent "culture" The cinema to-day is primarily an escape mechanism Newspapers distort the balance of truth in the service of political or financial interests, and are driven by competition for advertising into sensation-mongering The radio is as yet essentially a collection of scraps, a functional patchwork. Art as a communal function is moribund and needs to be recreated on a new social basis. Religion is in a similar position, and much of the population no longer feels its influence

The first need is to recognize that a free country, in this increasingly complex world, can not exist, let alone find satisfaction, without being self-conscious, and all the agencies of public opinion must be moulded to this end. A self-conscious society would be one in which every individual comprehended the aims of society, his own part in the whole, the possibilities of intellectual, artistic and moral satisfaction open to him, his rôle in the collective knowledge and will. But for this, as for correlation or planned control, the most elaborate organization is required

NATURALISTS IN THE WILDS OF BRITISH COLUMBIA

I. OUR WILDERNESS HOME AND LIFE IN WINTER

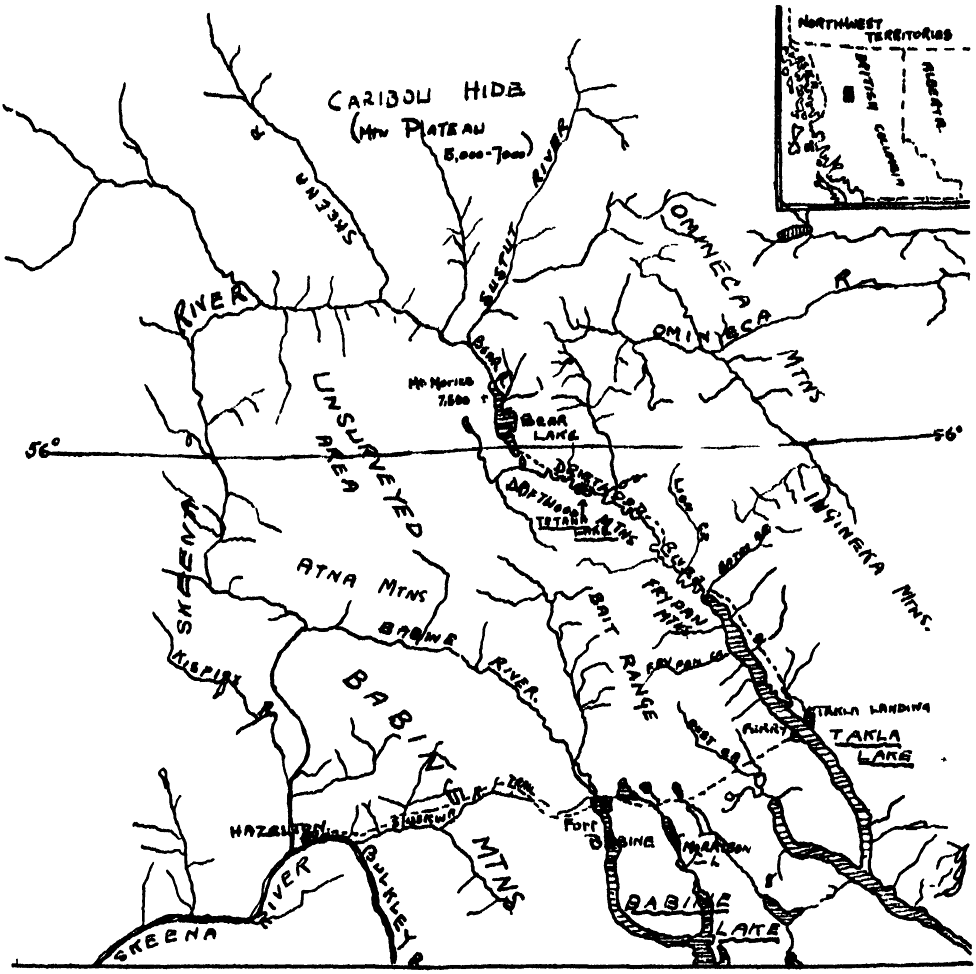
By JOHN F. and THEODORA C. STANWELL-FLETCHER
DIMOCK, PENNSYLVANIA

The Province of British Columbia on the west coast of Canada is a land of infinite bigness, variety, wealth and beauty, and with its 372,300 square miles of territory is larger by 50,000 square miles than the combined states of Washington, Oregon and California, or approximately equal in size to the combined areas of the United Kingdom, France, Holland, Belgium and Denmark. It is over one thousand miles long from southeast to northwest and extends over eleven degrees of north latitude from forty-nine degrees to sixty degrees. There are mighty rivers and inland lakes, great mountain ranges with lofty snow-clad peaks—many still unnamed and unsurveyed—great valleys and tremendous stretches of virgin forest, a combination which gives the province of British Columbia an unrivalled variety of topography, climate and habitat. This in turn makes for a flora and fauna of unusual richness and variety.

RED SQUIRREL. WINTER

Somewhere in the wilds of this province we had long wished to build a home where we could live a peaceful and simple life and study the flora and fauna in natural conditions throughout all the seasons. We felt the need of an existence which might lead to a greater physical and mental health than the one which was lived by most of our friends in modern towns and cities. One of us had many years of experience to his credit in the vast wilderness of far northern Canada, and we both had a fair idea of the great hardships and the great joys of life in the wilds and preferred it to any other.

Many years could well have been spent in roaming the British Columbia solitudes in search of the ideal spot, and so we were compelled to decide on at least a certain region. We chose the Driftwood River Valley, situated at about fifty-six degrees north latitude and over two hundred miles northeast of the southern tip of Alaska. It was off the beaten track and generally unknown to scientists. Mr. E. A. Preble had passed through there in July, 1913, but as far as we knew no real study had been made of the region. No doubt the presence on the map of a large area adjacent, marked "Unexplored," was a contributing factor in our choice. We had arranged with the Provincial Museum of British Columbia to send them the results of any small collections we might make. We were pleased to find that the powers-that-be in this province frowned on any large collecting expeditions from "outside" and did everything in their power to keep British Columbia material for British Columbia. This was a view-point with which we entirely sympathized, and

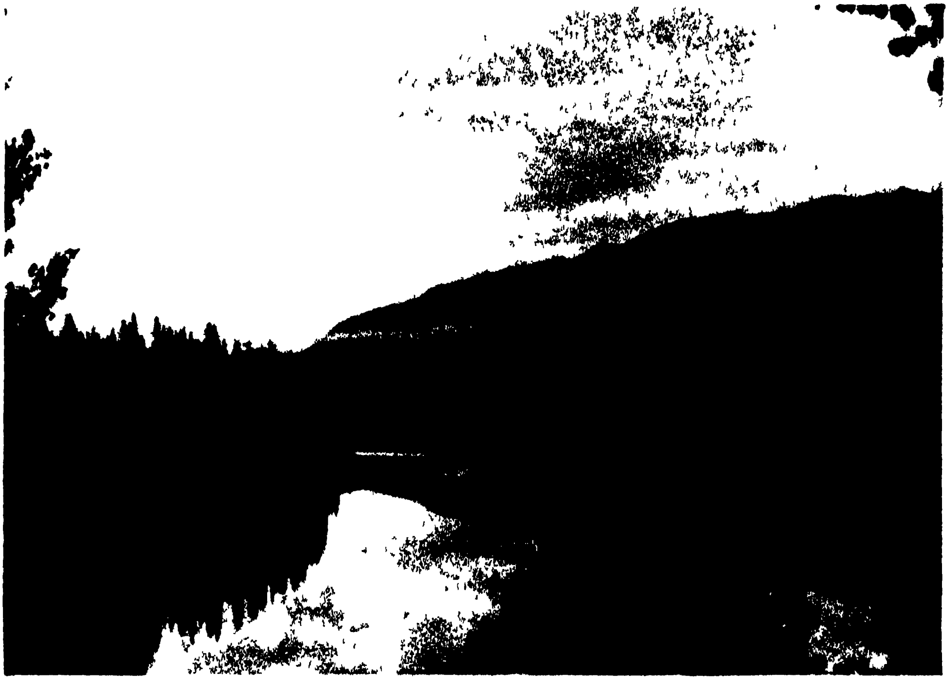


MAP OF THE DRIFTWOOD RIVER REGION OF BRITISH COLUMBIA
SHOWING LOCALITIES REFERRED TO IN TEXT SCALE 30 MILES TO AN INCH APPROXIMATELY.

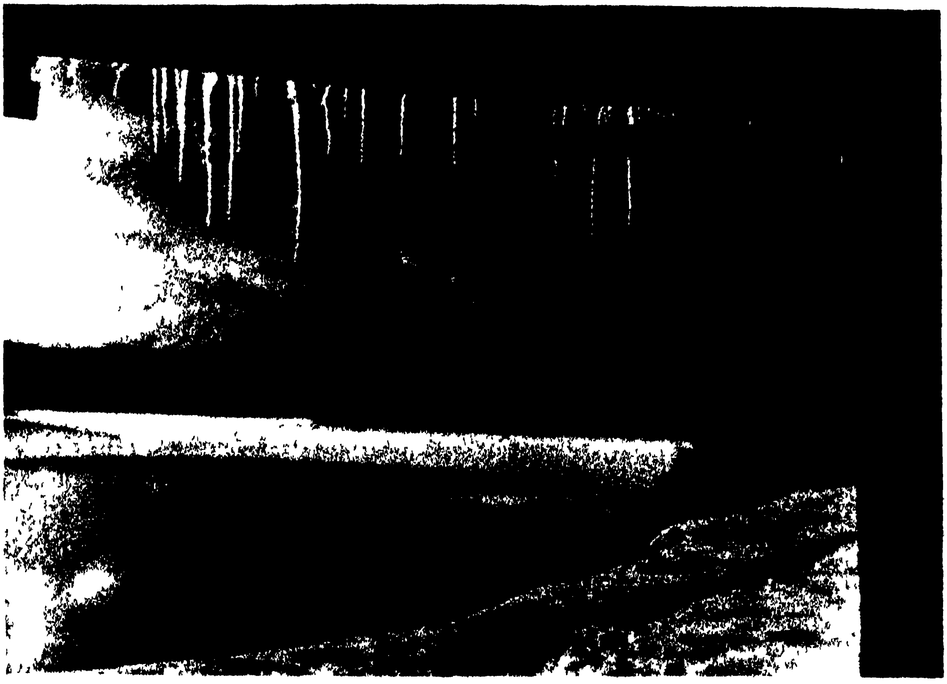
this policy, coupled with the isolation and difficulties of penetrating into that part of the country, should we felt, give us a chance to live undisturbed in our beloved wilderness

Our adventures really began at Lake Tetana in the late summer of 1937 While on the trail with guide and pack-horses from Hazelton, British Columbia, we had met an old Indian at Lake Babine who told us of this small "luffly lake—not like prison," from which we judged that it was not completely hemmed in by mountains or forest, as were the many hundreds of lakes in that country The man told us that from the lake one had a good view of the mountains around. On September 12th, after a two-weeks journey on horse-back over mountain passes and winding, overgrown trails, fording swift mountain streams and rivers, crossing mud holes and rotten log bridges, with the usual amusing and hair-raising episodes which go with a pack-horse trip, we reached the mile-long lake whose Indian name, Tetana, means "Flows into the River"

It was at the time of a clear sunset,



LAKE TETANA SEPTEMBER 1937



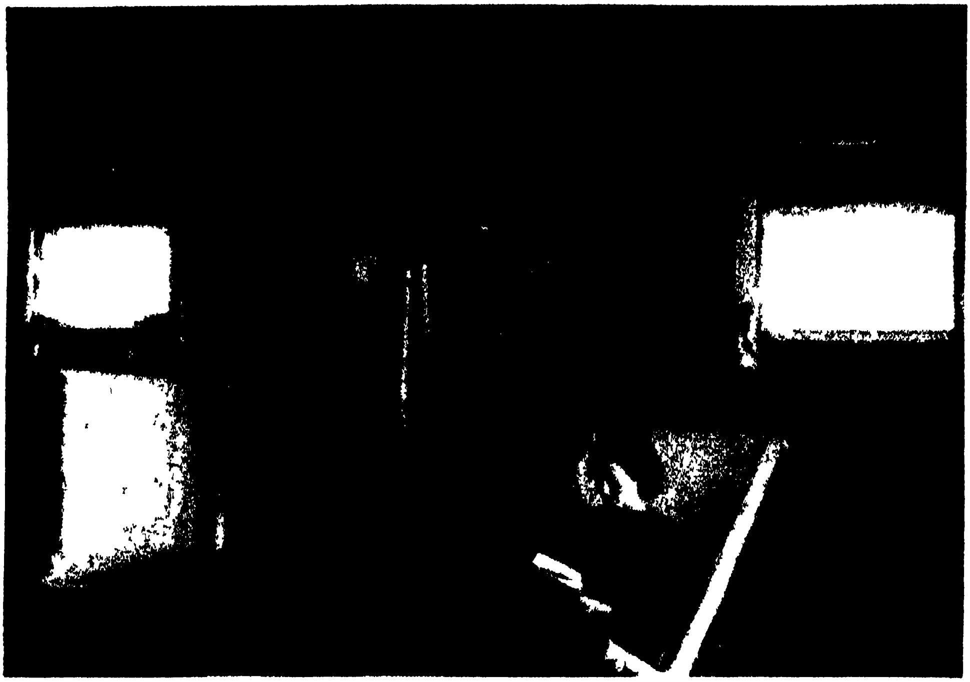
VIEW OF LAKE TETANA THROUGH CABIN FRONT DOOR NOVEMBER 1937.

and the crystal waters of the forest-and-grass-fringed lake reflected the nearby range of Driftwood Mountains. Tinted clouds floated on the still waters and towards the south end of the lake the reflection of the Fry-Pan Mountains, rugged, snow-capped and inviting, shimmered with the motion of ducks, loons and muskrats A coyote watched us from a curve in the lake shore not far from our camp.

Only one or two Indians who trapped in the vicinity, and practically no white men, knew or had ever seen this lake Takla Landing, the nearest settlement, of about seventy-five people, was some sixty miles away, the nearest automobile road and electric light two hundred, and the nearest railroad farther still At last we had our mountain solitude, and we had axes and a large saw, jack-pine trees for cabin logs and two Indian helpers Among our supplies were three large glass windows, still unbroken after the long journey on pack-horses, medical supplies, bedding, books, cameras, binoculars, warm clothing, coal-oil lamps and oil for the long winter nights; flour and sugar by the hundreds of pounds, bacon by the slab, hams, cheeses, sacks of vegetables and cans of everything edible Our fuel was already there, in the forest around us We had brought two sheet-iron stoves along with us; also a drum-oven in which to bake bread, cakes, pies and biscuits

DRIFTWOOD RIVER SOUTH OF LAKE TETANA. SEPTEMBER 1937

Soon after we started cutting logs for the cabin, having picked a site with a southern exposure, an airplane made a forced and hazardous landing on our small lake Ice on the wings, together with a blinding snowstorm, forced the young pilot down, and he and his mechanic remained at our camp for four days. Their undisguised astonishment when greeted by Mrs Fletcher in "this blank country" where only the odd Indian might be expected, was amusing



MRS FLETCHER AND CABIN INTERIOR DECEMBER 1937.

CONDITION OF FOREST IN WHICH WE HAD TO LOCATE DRY FIREWOOD.

Other whites from "outside," traders, game wardens and policemen, had shaken their heads at the thought of a young white lady choosing to live in these wilds—as far as possible from the settlements The senior writer was told that he had "no right to make any woman give up the proper life to live with the animals " These sentiments were due partly to the extreme isolation of the spot and partly because the local Indians had a bad reputation, somewhat undeserved, we later decided Any troubles or difficulties which we might encounter we should have to handle ourselves as best we could, for there were no neighbors to call upon and we were cut off from any communication with the outside world for months at a time The fact that we had no radio and did not want one horrified the white people, and when the Indians saw us trapping mice on a large scale, they spread the report that we were crazy. It took a year and a half for the whites and Indians to realize that we were normal people, quite harmless and not there for some unlawful purpose

By the first of October, there were many signs of the approaching winter, and it was a fight to get a decent shelter over our heads before the heavy snows came The autumn gold and burnt orange of the poplars (*Populus tremuloides* and *Populus balsamifera*) no longer lit up the dark blue-green of the spruces (*Picea canadensis*) and the yellow-green of the pines (*Pinus contorta*). Reddish willows and marsh grasses around the lake shore lost their color. The mountains glittered with fresh snow The cabin went up slowly, peeled pine logs thirty-five feet long were hauled by the pack-horses from the forest nearby, rolled, lifted and fitted into place The doors and windows were cut out as the walls went up Moss by the sackful was packed and chinked between the logs, outside and inside; a

OTTER SLIDES ON ONE OF MANY MAPPED LAKES IN DRIFTWOOD VALLEY.

CABIN AND PROVISION TENT NOVEMBER 1937

small cellar was dug. We worked long hours and went to bed each night in an exhausted condition We had, of course, no lumber, and so we cut and split trees down the middle, hewing them into boards for roof and floor, shelves and tables Eighty-four axe-hewn boards ten feet long and eight inches wide made the cabin floor alone, and, on the flat-hewn roof boards and rafters, went two thousand five-hundred shakes, split laboriously by hand from fir tree blocks and carried from a mile away The cabin interior measured thirty feet by twenty But the snow had come long before this was completed The Indians had been too long away from their homes, one of them lived over two hundred miles away To be caught by winter without proper preparation in that country was a serious matter, and so they refused to stay after the first real snows came On October 21st, we waved good-bye to our helpers and the fine little pack-horses and were left to the vast silence of the autumn wilderness and to our own resources On October 31st we moved into the cabin, we had been tent-dwellers long enough But we missed the nightly raid by the inquisitive and thieving weasels (*Mustela cicognani richardsoni*), the early morning visits from tiny gray-headed chipmunks (*Eutamias minimus caniceps*), the cries of owl, wolf and coyote, and all the strange, hushed night sounds from the deep forest around our seemingly insignificant camp

We set about furnishing the cabin In addition to the three glass windows, we put in four others made from a type of mica glass which is obtainable in rolls Thus, with the two doors, we had ventilation and plenty of light, with views in every direction of the glorious country around us None of the stuffy one-windowed cabins for us, such as we had seen in other parts of this country, whose owners apparently missed completely the beauties and interests of the wildlife around them Comfortable beds and arm chairs we made from a framework of small poles, with rope and canvas

REAR VIEW OF CABIN, MEAT CACHE AND SAWHORSE FOR FIREWOOD

stretched between. Shelves, tables, bookcases and a desk were made from the cases in which our freight had been packed and from hewn pine logs. On our book shelves was a collection of Barrie's Plays, Kipling, Shakespeare, "Winnie-the-Pooh," some poetry, Seton's "Lives of Game Animals," Taverner's "Birds of Canada" and many other reference books on the flora and fauna of British Columbia, a number of "Digests" and a few novels. Bear-skin rugs on the floor, curtains at the windows and the rich brown and yellow satin finish of the peeled log walls made the cabin attractive.

In the meantime we had three or four visitors from the small Indian settlement thirty miles north of us on Bear Lake. These were our closest neighbors, and their trapping lines ran near our vicinity. And these were some of the people about whom we had been warned. They were taller and stronger looking than the Indians we had seen at Babine and Takla Lakes, and seemed to have greater character of their own, due no doubt to their more isolated position and to the fact that they had had less contact with white civilization. The five or six different families at Bear Lake to which they belonged, appeared to be mixtures of the Babine Indians to the southwest, the Sikanees of the country to the northeast and Tahltans from the north. At first we eyed each other with mutual reserve. On the surface they seemed fairly polite and obliging, and we in turn tried to make it clear that we were come as strangers into their country and did not wish to interfere with their lives or cause any trouble. The older ones spoke and understood a very simple type of English. We were, during the ensuing eighteen months, to see a good deal of these Bear Lake Indians, especially the members of the two families who trapped and hunted near us. We went on various trips with them, and on two occasions slept in their crude cabins when

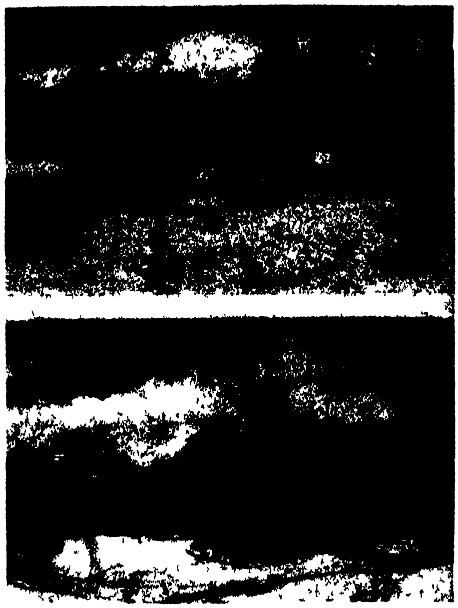
LAKE TETANA SHOWING OPEN WATER NEAR THE CABIN DECEMBER 1937

BEAR LAKE CHARLIE AND HIS WIFE SELINA BY THEIR CABIN AT BEAR LAKE. JANUARY 1938

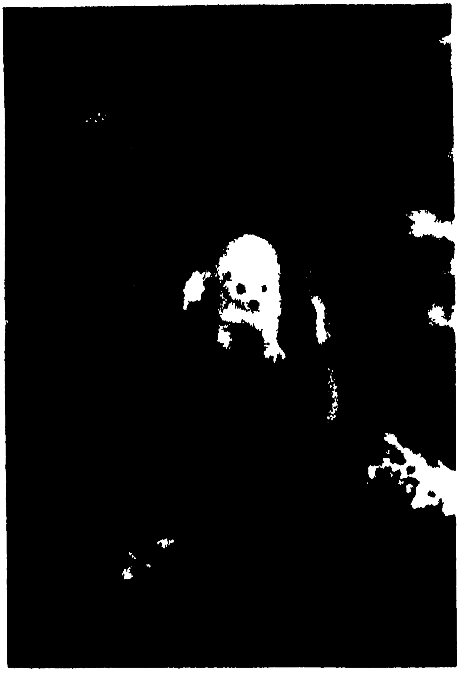
caught in winter storms At times they camped near our cabin while they were doing small jobs of work for us When they made their few journeys past us to visit their trap lines during the hard winter months, we invited them into the cabin for hot tea and biscuits, told them what we could of our work for the Museum and our ideas of conservation We acquired from them in turn valuable bits of information about the wildlife around us Our mutual interest in wildlife was always a common meeting ground and source of conversation When it came to doing any sort of business, they were a peculiar and difficult people to deal with Most business deals were both angering and exhausting They made fair guides, were excellent in traveling on the trail and had camping out, under all sorts of conditions, down to a fine art Their powers of endurance in all weathers, improperly clad and with what we considered a completely inadequate diet, consisting often of tea, bannock and perhaps not even meat, were remarkable But steady work, such as the average white man knows it, for more than a few days at a time was definitely not their forte

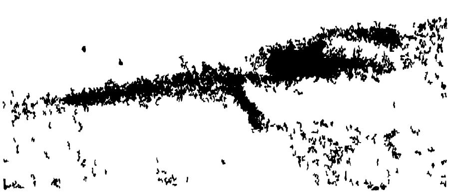
It is just as absurd to lump all Indians together and imply that they are all alike as to expect all the members of the white race to have characters in common It was always surprising to us to find how many white people, even those that claimed to know them, had this idea Although the Indians of this region had certain customs and traits and morals in common, individuals, members even of the same family, differed as to character and personality just as do members of the white race Those with whom we came in contact, with certain exceptions, had no idea of truth as we understand it, nor could they be relied on At one time they were friendly and even affectionate, at another for some known or unknown cause, they might be hostile and extremely unpleasant They were very sensitive and had a remarkably keen intuitive sense closely akin to the wild animals. They all seemed to have a sense of humor and adored practical jokes, and their "tallest" excuses and stories were often accompanied by an obscure twinkle. They had the peculiar Irish trait of being able to make you feel comfortable and elated or quite the reverse.

We had seen and handled natives of other races and color in various parts of the world, so that differences in morals and habits did not disturb us unduly One of us, who had lived in the Eskimo country for several years, found the Indians of our particular section of British Columbia decidedly inferior to the Eskimos as he had known them These Indians seemed to us to be in a rather sad state of transition They appeared to have lost their old strong racial and tribal characters and customs and to have acquired only the poorer characteristics of the white race



CABIN BY MOONLIGHT AND DAYLIGHT.
NOTE DIFFERENCE IN SNOW LEVEL IN LOWER PICTURE, SINCE THE MOONLIT NIGHT TWENTY EIGHT DAYS BEFORE





WEASEL AND WEASEL TRACKS

By Thanksgiving Day the branches of the trees were bent beneath their burdens of snow, and on the level ground there was a mantle three feet deep. Our lake, since it was fed by many springs along the north shore, was only partly frozen over, it was apparently the only lake of its kind in that part of the country. The springs were constant both in quantity and temperature Temperatures taken on December 26th with the thermometer outside on the cabin wall registering forty-three degrees below zero, Fahrenheit, showed the springs near the cabin to be thirty-eight degrees Later, during the month of August, when the thermometer showed eighty-eight degrees Fahrenheit in the shade, temperatures were again taken and still read thirty-eight degrees

Through the early part of the winter, three Barrow's golden-eyes (*Glaucionetta islandica*) occupied the stretch of open water and became quite tame, while two pairs of dippers or water ouzels (*Cinclus mexicanus*) remained until spring These dippers spent the winter in or around the open spring-fed patches of water in our lake On a cold winter's afternoon with the temperature around zero, at the end of December, we were startled by a shower of rippling song above our cabin This song was a cross between a song sparrow, mocking-bird and thrush, and was our first introduction to the dippers After that they sang to us all winter, the colder the weather the more they seemed to like it They sang lustily on mornings when it was forty below zero, flying through the air, darting down into the icy water, chasing each other Often they sang high in the air, dropping down with a shower of notes like a skylark They were strong, swift flyers, not to mention their remarkable aquatic powers in the water They could swim under the water or on top, float like a duck, dive off a

log or ice bank like an otter, only to come up dry and merry and sparkling. They spent considerable time feeding on insects under water or along rocks. In December on two occasions we saw a male and female (?) performing the act of coitus At first it occurred in the water, and a few minutes later on a snow bank, with much twittering and fluttering of wings These birds used to chase each other over our cabin and in the nearby woods, often in full song Whether it was one male chasing another male, or a male chasing a female, we could not always be sure They were quite tame and when we went down the bank to get water would often fly over to us and start feeding a few yards away Sometimes one dove in a small hole in the ice and swam under the ice for a distance of two or three yards, coming up through another hole nearby They became scarce by March 10th, and had left our lake by March 19th But they were seen at open patches of water along the river until June, when they apparently disappeared for their nesting grounds

Early in December, the tent which we were using as a storehouse behind the cabin, broke down from the weight of snow which fell in a single night When we dug it out and cleared everything from underneath we discovered some missing specimens which had been stolen by a weasel during the late fall Two Franklin's grouse skins (*Canachites franklini*) and one made-up white-footed mouse (*Peromyscus maniculatus borealis*) with the cotton-wool bulging from a tear in the throat, were retrieved, and a very annoyed weasel permitted us to shoot him with our cameras This weasel was one of our most persistent and amusing companions His eyes, red or green with changing lights, never lost their wicked impish expression He appeared and disappeared with miraculous rapidity and his lithe, snaky, undulating movements held an absolute fascination When we had been in the tent in September and October he made himself very free of our quarters, sometimes running over our bodies at night He was brown above and cream below when we first saw him in late September, but

CANADA JAY AND RED SQUIRREL

with the first snows in October, his coat became more and more splashed with white, until finally he was creamy white all over, with a black brush on the end of his expressive tail

Cutting wood for two stoves occupied

a considerable portion of our time Our helpers in the fall had not stayed long enough to cut a reserve supply With so much snow on the ground it was necessary to find dead trees in the woods, tap them with the axe—and leap aside on snowshoes, before hundreds of pounds of snow fell from the branches above If one was slow, or tripped over one's snowshoes, as often happened, the deluge was cold and heavy and one was knocked flat and buried Logs eight or ten feet long were cut and carried on our shoulders to the cabin, sawed up and split Blisters and inexperience gave way to hardened hands and decent axe-work after the first few weeks

CANADA JAY

We were fairly well supplied with fresh moose (*Alces americana* ssp) meat at this time The Indians brought us bits from newly killed moose, and we froze all that we did not need for immediate use as a reserve supply for winter Moose tongues, hearts, livers and kidneys were especially good Later in the year one of the Indians showed us how to cook antlers in the velvet, and these were delicious We killed very few moose ourselves and these only for food, as we were not at all interested in big game hunting and wished to spread the doctrine of conservation as far as possible We had also occasional meals of mountain goat (*Oreamnos americanus columbiae*) and bear (*Euarctos americanus*) meat, grouse and wild ducks

By December 10th the temperatures were averaging four to ten below zero, Fahrenheit, each morning and, on rising, our first act was to light the fire in the larger stove Canada jays (*Perisoreus canadensis canadensis*), with their feathers fluffed out from the cold, demanded attention at our feeding station, and chickadees (*Penthestes gambeli grinnelli* and *Penthestes hudsonicus columbianus*) waited with them The jays, or "Camp Robbers," were bold and friendly, coming to our outstretched hands for food, when called by a whistle They learned to know when we were leaving the cabin for a few days trip, carrying packs, and would follow us for half a mile or so, scolding harshly from the tree tops They also knew when we were returning, for on many occasions they met us when we were a mile from the cabin and flew around us with many a coo and trill, all the way back to the cabin

The long quiet winter evenings in the warm cabin with the snow piled high outside the windows were a never-ending joy. By mid-December the sun set behind the mountains at 1 30 P M , and it grew dark at 3·30 and was not light again until 9 00 A M By 4·00 P M we settled down to read and work and play games with the knowledge that nothing and no one would disturb us. Each evening was a perfect balm to the nerves and we were never bored

We were beginning to feel acquainted with the countryside Endless numbers of small hills and ridges rose gradually to mountain ranges on the east, and more abruptly to the steep Driftwood Mountains on the west. There were hundreds of lakes, large and small, in every direction Willow swamps, interspersed with small grassy meadows, beloved of moose, and sphagnum bogs alternated with the heavy stretches of forest In the swampy lowlands these forests consisted of heavy black and white spruce (*Picea mariana* and *Picea canadensis*),

and some balsam (*Abies lasiocarpa*) On the moist slopes of hills and mountains, it was often composed of almost solid stands of magnificent balsams over one hundred twenty-five feet in height, with impenetrable undergrowth of Devil's-club (*Fatsia horrida*) and small shrubs The dry ridges and old burnt-over places were covered with jack-pine (*Pinus contorta*) and poplars (*Populus tremuloides*) We climbed all the small hills around us for views of the untouched wilderness which was always different with changing lights, now utterly silent in the depths of winter A cry or shot from one of us was instantly muffled by the snow-laden trees Sometimes the snow came down for days, as though a giant flour-sifter had been turned on During the winter there was seldom any wind and after each fresh snowfall we were able to flounder about on our snowshoes only a few miles a day Animal signs were scarce The animals could not get about even as readily as we could We found that it was absurdly easy to become completely lost in this country Blazes on trees as trail markers, which had been made shoulder height during the autumn, were at or below the snow level, the snow-laden trees looked all alike to us, while the mountains nearby were not visible from the floor of the forest Once, on a bright sunny day, one of us discovered, after following a marten track (*Martes americana actuosa*) for some hours, and noting where it had nearly succeeded in catching a grouse or had stalked a red squirrel (*Sciurus hudsonicus columbiensis*), that he was in a strange part of the woods Actually he was within two hundred seventy-five yards of the cabin, but it took two hours of backtracking on the snowshoe trail to find this out

On one very snowy morning, at dawn, we saw from our windows a moose on the lake where the ice was firm at the southern end A day later, when we got up to light the morning fires we saw something surprising In the open water below the cabin a Barrow's golden-eye paddled aloofly and indignantly away from a snow-white varying hare (*Lepus americanus pallidus*), which was then forty feet from the shore and going through the water with tremendous thrusts from its large hind feet After a few more strokes it hesitated, turned and swam back, then was lost from sight behind the snow bank On investigating its tracks in the snow we found that the hare must have entered the water deliberately, for there were no signs of other pursuing tracks It had spent a moment on the shore after emerging, left a few pellets, and then leisurely headed back toward the woods where its trail was lost among dozens of other hare tracks and runways We could not see any reason for this morning bath, and wondered how the animal dried its fur and survived—if it did.

At 7 00 A M. on Christmas Day our maximum and minimum thermometer, which registered fifty-two degrees below zero, Fahrenheit, was jammed by the mercury being forced around the indicator, which was wedged into the upper bulb, where it remained The same day, what we took to be an otter, left a cleaned and decapitated Dolly Varden trout (*Salvelinus malma*) weighing two and one-quarter pounds, on the edge of the snow-covered lake ice near the cabin Our mouse traps were producing few specimens, and so on New Year's Day, 1938, we started on an exploration trip toward Bear Lake We did not know the correct trail route, and the summer trail was buried under the snow, the blazes hidden But we had plenty of time, food for a week in our packs, an axe and some bedding, and the inevitable cameras, binoculars, skinning kits and rifles, slung around our necks. Our snowshoes were long and narrow, upcurved at the toes, and made a good trail by which we could (we hoped) find our way home again—providing no more snow fell while we were away.

We found moose tracks plentiful and

saw a number of Franklin's grouse; along the shores of some of the frozen lakes were fox (*Vulpes fulva abietorum*) and mink tracks (*Mustela vison energumenos*), and on one lake there were signs of three otters (*Lutra canadensis evexa*) which had traveled over the surface, running a few paces and then folding their legs to their bellies and sliding on the snow for a distance of ten to fourteen feet at each slide Once or twice we saw fisher tracks (*Martes pennanti columbiana*) in the thick and tangled forest This country was part of Indian Sapolio's hunting grounds, and we found later that here at any rate was one Indian who apparently made an attempt to conserve his fur bearers, for he kept a count of the numbers of animals on his line, and the years in which he trapped them, allowing definite periods to elapse when the took no skins of a certain species We can not say the same for the majority of the people in that region

At nights we "siwashed," or slept under a large tree with a fire made of four or five big logs before us Below the trees the snow was less deep and our fire, after the first hour or so melted the snow until the burning logs were level, or below, our bed of spruce branches and "ground-hog" robes, made by the Bear Lake Indians from the local hoary marmot (*Marmota caligata oxytona*) Sometimes it was bitterly cold, the great fire melted the snow around us and made our moose-skin moccasins wet, if we moved away from the blazing logs we froze Many of the nights were wonderful On black ones, the glow of the fire lit up the big spruces and shut us in a room of red light and shadows When it was moonlight, the mountains and forests around us were light as day in their glistening blanket of snow But when our food supply was low and we were hungry and dead tired after a long day, the marvelous beauty around us often seemed utterly impersonal and unreal

During this short trip we made several discoveries; first, that pack-dogs, used universally in that country by the Indians for carrying supplies, would be a blessing to tired shoulders and aching backs Second, that every moose in the country was heading southward and not resting on the way From the Indians we later learned that this year there was a general southerly movement by the moose in all parts of the district, and the older men told us that this indicated a heavy snowfall in the near future

There were no signs of wolves (*Canis* sp) at this time, though many were to be seen later, and when the snow was really deep, eight feet on the level, those few moose still in our vicinity had a sorry time of it We noted that in order to travel across open places where the snow was deepest, they bent their forelegs at the knees and used their lower legs as snow-shoes This packed the snow somewhat, and enabled them to keep their bodies near the surface

Note. Annotated lists of plants and animals collected will be published elsewhere after further study and when identifications are completed All illustrations have been made by the authors

GEOGRAPHIC INFLUENCES ON ALAND'S WINDJAMMERS

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THE romantic windjammers of the Åland Islands, which just now are one of the chief objects of Russia's attack on Finland, have probably been a greater influence in advertising this Baltic archipelago (Fig 1) than any other phase of its geography Each year newspapers, magazines and books carry columns about the annual grain race from Australia to northwest Europe Each year the Ålands are pictured as the home of the last of the great sailing fleets Each year Captain Gustaf Erickson, the owner of the Åland Islands' fleet, comprising the most of the thirty or more large windjammers of the world, gives a few interviews to tourists visiting Mariehamn, the capital of the Ålands (Fig 2).

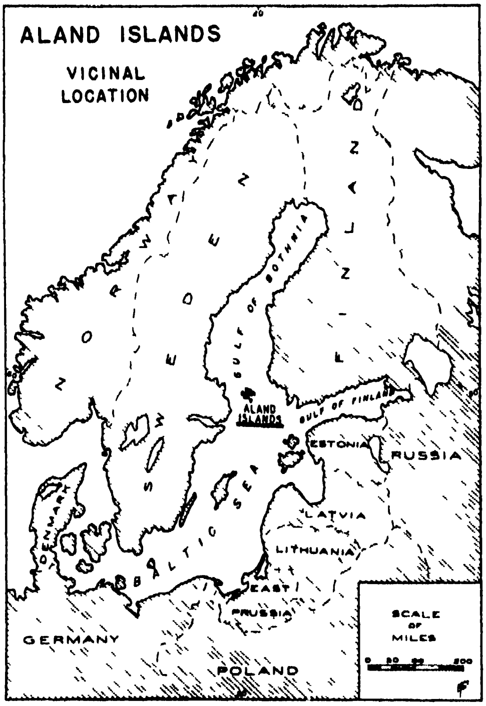

FIG 1 THE ÅLAND ISLANDS

THE ÅLANDS COMPRISE OVER SIX THOUSAND ISLANDS WITH AN AREA OF APPROXIMATELY FIVE HUNDRED AND FIFTY SQUARE MILES, BUT THE TWENTY FIVE THOUSAND PEOPLE, WHO LIVE MAINLY BY FARMING AND FISHING, OCCUPY ONLY EIGHTY OF THE ISLES THE ARCHIPELAGO BELONGS TO FINLAND AND FORMS A DIVIDING ZONE BETWEEN THE BALTIC SEA AND THE GULF OF BOTHNIA, AND A BUFFER BETWEEN THE SCANDINAVIAN PENINSULA AND THE EUROPEAN MAINLAND

It was the author's good fortune to secure such an interview near the close of a round-the-world trip in 1936 As a geographer I was interested to learn whether geography can account for the last stand of the barks, barkentines and full riggers in the land of six thousand islands "Is there something peculiar about the climate, the location or the land forms of Åland, the largest isle of the Åland Islands, which attracted the owner of this fleet of sailing vessels?" I asked Mr Erickson replied in the negative, and indicated that any one of a number of ports in northwest Europe could qualify as the home of the sailboats just as well as Mariehamn Stockholm, Oslo, Bergen or Copenhagen would serve the purpose equally well The human factor, too often little stressed in geography, holds the answer to this question Man is given a choice within a general area as to where he may carry on this industry, just as he is usually given a choice within certain limits in determining the location of many other world industries Captain Erickson chose Mariehamn (Fig 3) as the home port for his sailing fleet largely because his home is in the Åland Islands and he loves the strategically located Baltic archipelago. Moreover, his choice can be defended from a geographic standpoint The capital of the Ålands pos-

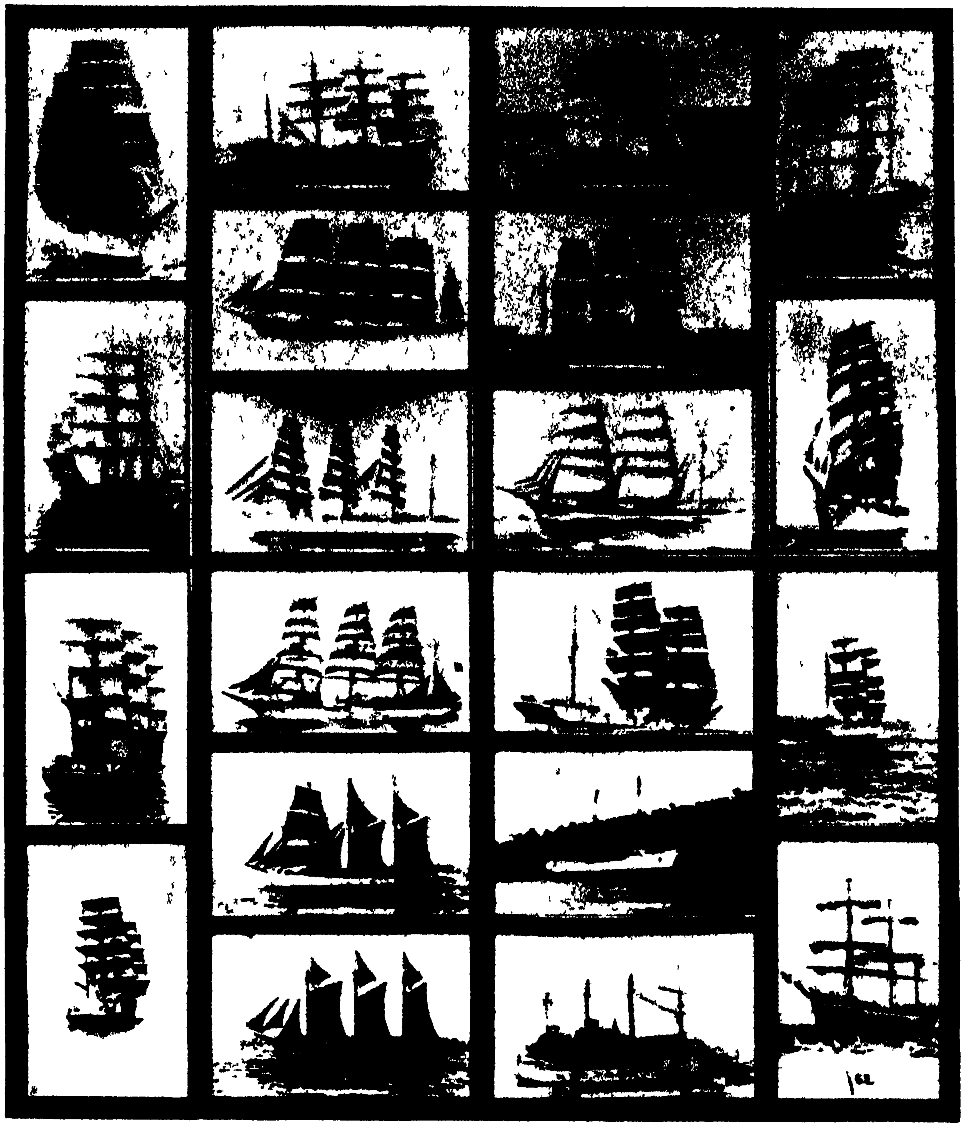

FIG 2 TWENTY OF CAPTAIN ERICKSON'S SAILING SHIPS

sesses a good harbor which is not too far away from the dense populations of northwest Europe, who afford the market for the wheat cargo of the windjammers

Although the physical geography of the islands played a minor rôle in the final choice of a home for the sailing fleet, physical factors are extremely important in the choice of the routes followed and other phases of the sailing ship grain trade One of the most important influences is climate Sailing from Mariehamn to Australia involves a passage through all of the world's major wind belts except the belts of the polar easterlies The westerlies, subtropical calms, trade winds and equatorial calms are all encountered on the journey to and from Australia (Fig 4)

To illustrate the wind conditions encountered by the sailboats on their voy-

age for wheat from Mariehamn to Port Lincoln, Australia, the writer has prepared a map of the world wind belts and on it indicated the route usually followed by the windjammers Of necessity the wind directions shown are highly generalized and the polar easterlies as well as the Asian monsoons are entirely omitted Moreover, the trades and westerlies are shown blowing from their most dominant directions, whereas any student of climatology knows that on many occasions their paths are far different from text-book illustrations In spite of these omissions, the author feels that the map may be useful as a practical teaching device for students beginning the study of world wind belts, and the preparation of the map was largely motivated by this aim

Invariably the fleet makes the trip out from northwest Europe by rounding the Cape of Good Hope at the southern tip of Africa and sailing eastward to Australia with the aid of the westerlies On the return, with full cargo, the start of the 14,000-mile journey is likewise encouraged by these winds, for the ship's prow continues eastward around the Horn, at the poleward point of South America, in an ocean area which demands the best of the sailor's skill while passing through this home of the "Roaring Forties" Not always are the westerlies an advantage to the windjammers, for according to Captain Erickson, they may cause the greatest delay encountered on the journey It is when the ships leave Mariehamn in August and September that the greatest trouble may occur During this period, southwest winds usually prevail, and the captain stated that on one voyage his ship took twenty-nine days to travel from Mariehamn to Copenhagen, a distance which can easily be made in two days with favorable winds This occurrence is unusual, of course, but it is well to remember that the westerlies may be as fickle in direction and consistency as other winds with more notorious records. While the prevailing winds and storm movements are from the west the air may move from every point of the compass, a fact well illustrated by wind frequency in the Scilly Islands lying in this wind belt just to the south of England (Fig 5)

Once out of the belt of the westerlies the ship, if it is fortunate, may find north winds around the Azores high off the southwest coast of Spain (Fig 6) With their aid and that of the south-flowing Canaries Current, the windjammer can easily sail into the belt of the northeast trades, where strong consistent winds blowing day after day against giant sails will push the Australia-bound boat rapidly equatorward (Fig 7)

Approaching the equator, the sailing ship usually crosses the dreaded equatorial calm belt between 25 and 28 degrees West Longitude, a little west of a north-south line directly south of the Cape Verde Islands Here the doldrum belt reaches its narrowest extent, and if the gods of luck are smiling, the craft may encounter no calms at all Such was the good fortune of the Erickson boat *Lawhill*, which in 1921 found neither horse-latitudes, nor doldrum conditions from Biscay to the Line Instead, the freighter sailed swiftly across the equator on August 31, pushed forward by the northeast trades which graciously extended themselves beyond their usual boundaries into the belt of the southeast trades (Fig 7)

While these winds lend less assistance to boats journeying to the Antipodes than those blowing from the northeast, skilful sailing may get the boat through their territory in two weeks' time or even in a shorter period The southeast trade winds may be lost near the small isle of Trinidad, 20° 20′ South–29° 40′ West, where counter-clockwise northwest winds around the subtropical high enable ships to get southward and eastward (Fig. 8), and by the time Tristan de Cunha, 35° 30′ South–12° 15′ West, is reached they en-

FIG 3 THE HARBOR AND PART OF THE TOWN OF MARIEHAMN

THE ÅLANDS' CAPITAL, WHICH IS LOCATED ON THE SOUTH SHORE OF ÅLAND ISLAND, THE LARGEST OF THE GROUP, HAS A POPULATION OF ABOUT 1,000 PEOPLE AND IS BECOMING A POPULAR SUMMER TOURIST TOWN.

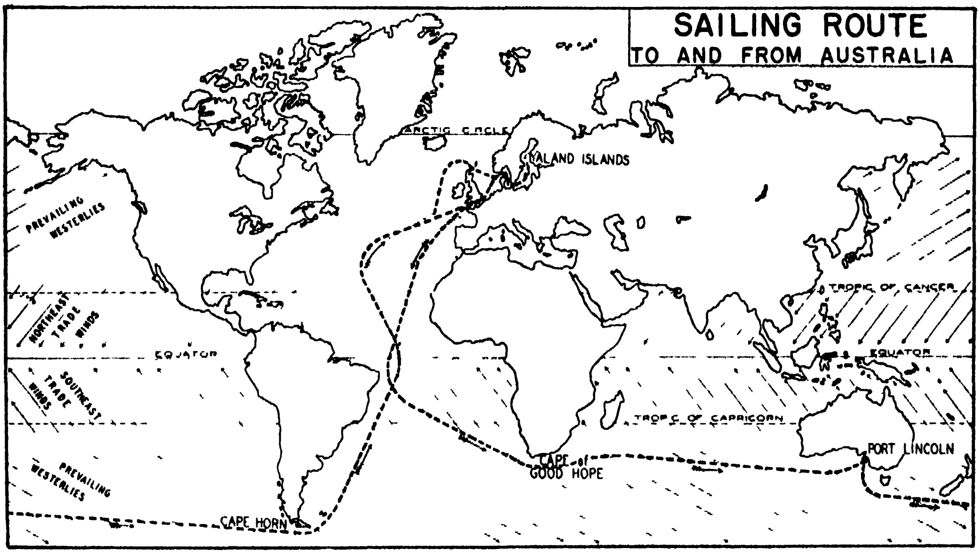

FIG 4 SAILING ROUTE TO AND FROM AUSTRALIA

SHIPS FOLLOW THIS GENERALIZED ROUTE MOST OF THE TIME, GOING OUT BY WAY OF GOOD HOPE AND COMING BACK AROUND THE HORN WIND BELTS AND WIND DIRECTIONS ARE OF NECESSITY DRAWN HIGHLY DIAGRAMMATIC, AND THE POLAR EASTERLIES AS WELL AS THE ASIAN MONSOONS ARE ENTIRELY OMITTED

counter the westerlies which, a little farther south, sweep eastward whatever comes into their path Once into this desired path, the windjammers find easy sailing for Australia, and after loading cargo these same strong winds propel them well on their way homeward A J. Villiers, in his interesting narrative, "Falmouth for Orders," tells of the *Herzogin Cecilie*, an Erickson boat, making the 5,000-mile stretch from New Zealand to the Horn in 17 days—an average speed of approximately twelve and one-half miles an hour, or three hundred miles a day (Fig 7)

In contrast, the trip from the westerly belt through that of the horse-latitudes may be as slow and tedious as beating head winds from Mariehamn to Copenhagen Turning again to Villiers' book, Captain Erickson read a passage telling of the trials encountered by the *Herzogin Cecilie* after reaching Cape Horn from New Zealand in 17 days For 27 days she slowly made her way from the tip of South America to a point at 21 degrees South Latitude into the southeast trade wind belt On this homeward stretch the counter-clockwise northwest winds around the subtropical high, which usually help on the way out to Australia, persistently opposed the ship's progress Her average speed from the westerly belt through the horse-latitudes to the trades of approximately one hundred miles a day was less than one third the rate made with the help of the westerlies

The southeast trades may give the home-bound ship speed nearly as swift as that achieved in latitudes below the Horn, especially if the wind has a stronger southerly than easterly component. Passing from 21 degrees South Latitude to 4 degrees South Latitude the *Herzogin Cecilie* made approximately 1,200 miles in five days—not quite as fast as the jaunt to the Horn from New Zealand, but still fast sailing for a windjammer

The passage through the latitudes of the equatorial calm belt (Fig 7) is seldom as easy as that of the outgoing *Lawhill* mentioned some paragraphs above. In contrast, the *Herzogin Cecilie* found conditions about as Columbus found them when he crossed the Line on his memorable third voyage to the Americas Just as the great navigator waited day after day for a favorable breeze, so did the crew of the *Herzogin Cecilie* as they cursed the calms, light winds and rain, the three demons which haunt sailing

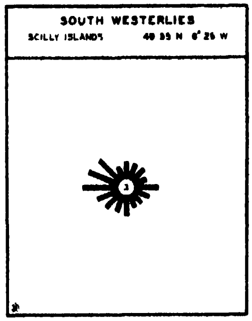

FIG 5 SCILLY ISLANDS

MOST MARINE STATIONS IN THE BELT OF THE SOUTHWESTERLIES SHOW A HIGHER PERCENTAGE OF WESTERLY WINDS HOWEVER, THIS STATION WAS CHOSEN TO EMPHASIZE THE FACT THAT WINDS IN THIS BELT MAY BLOW FROM EVERY POINT OF THE COMPASS DATA FROM "CLIMATE," P 103, BY W G KENDREW

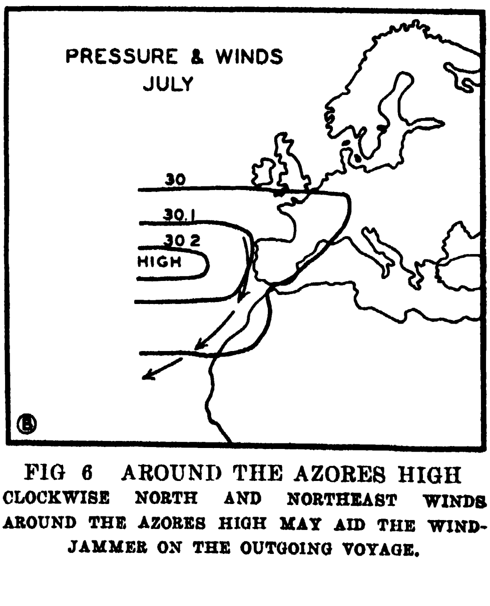

FIG 6 AROUND THE AZORES HIGH

CLOCKWISE NORTH AND NORTHEAST WINDS AROUND THE AZORES HIGH MAY AID THE WINDJAMMER ON THE OUTGOING VOYAGE.

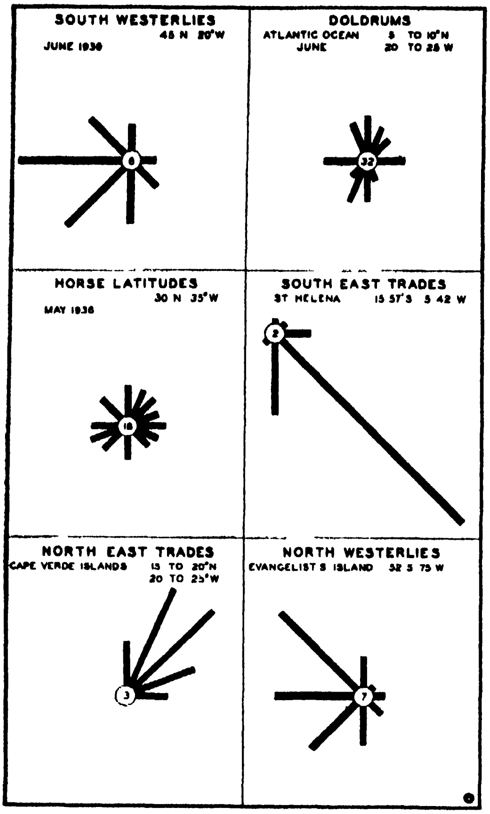

FIG 7 WIND ROSES

TEMPERATE, SUBTROPICAL AND TROPICAL WIND BELT THE ABOVE ROSES SHOW DIRECTION PERCENTAGES FOR TYPICAL LOCATIONS IN THE MAJOR WIND BELTS THROUGH WHICH THE WINDJAMMERS PASS. NO ROSES ARE GIVEN FOR THE HORSE LATITUDES AND DOLDRUMS OF THE SOUTHERN HEMISPHERE, BUT THEIR WIND CONDITIONS ARE SIMILAR TO THOSE OF THE CORRESPONDING BELTS OF THE NORTHERN HEMISPHERE DATA FOR ALL WIND ROSES, WITH THE EXCEPTION OF THAT FOR EVANGELIST'S ISLAND AND ST HELENA, WERE OBTAINED FROM CHARTS FURNISHED BY THE U. S HYDROGRAPHIC OFFICE, WASHINGTON, D. C. THE STATISTICS FOR ST HELENA WERE TAKEN FROM "CLIMATE," P. 90, BY W G KENDREW, AND THOSE FOR EVANGELIST'S ISLAND WERE OBTAINED FROM "CLIMATES OF THE CONTINENTS," P. 317, BY W. G. KENDREW.

ships as they attempt to sail across the earth's bulging waist line.

Windjammer captains encountering the northeast trades after a siege in the doldrums may or may not be much relieved. If the winds come directly from the northeast, the ship will find it difficult opposing these helpmates of the outgoing voyage. If the trades are more easterly than northerly, the problem will be less troublesome Once out of the tropics, the calms of the horse-latitudes may encourage cursing as loud and vociferous as that expressed in the doldrums (Fig 7). But when this barrier is passed, the ship enters the westerlies of the Northern Hemisphere and with their southwesterly urge blowing on its full-spread sails, the windjammer can quickly carry its cargo of wheat to the final destination (Fig 7).

The preceding paragraphs illustrate how geographic factors influence the whole journey of the windjammers. Each wind belt contributes its favor or withholds it, depending on the time of year the voyage is made, the route the ship takes, whether with or against the prevailing wind, the selection of a course through the wide or narrow section of any specific wind belt and many other geographic conditions If the gods of wind and sea smile with favor, the windjammer may make the journey swiftly and with ease, but if wind and wave are unpropitious the voyage may take two or even three times as long The swiftest passage ever made from Australia to the British Isles by an Erickson boat was completed in approximately 63 days, but most return jaunts consume at least 80 days. The *Herzogin Cecilie,* winner of the 1936 derby, took 86 days before being wrecked on the Devon coast at the end of her run

Not only does geography influence the choice of routes and the sailing time of the windjammers, but it also shows itself in the varied nationality of the members of each vessel's crew of twenty to thirty men. As an example, the *Passat,* which won the grain race in a recent year, carried what might be called an international crew Sailors from Russia, Sweden, Finland, Belgium, France, Germany, England and the United States were listed on its payroll. The wind-

jammer is not troubled with the problem of "shanghaiing" a crew, as were many of the clipper ships of the 1850's On the contrary, officers have to keep a constant watch in port to keep off stowaways Moreover, most of the best navigation schools require a year of experience on square-rigged ships before admission, so boys looking to their mate's papers are eager to sign for five dollars a month and their keep, some actually pay for a chance to sign, with the opportunity it offers for a sail around "Cape Stiff" in a real square-rigger

The low cost of hiring a crew is but one of the economies practised by Captain Erickson in operating his fleet of sailing ships The initial cost of each vessel is also ridiculously low After the war, when the Captain began to accumulate his windjammers, the shipping industry was depressed lower than the average wind velocity in the doldrum belt Most shipping companies cut down their holdings radically, especially holdings of sailing ships, and made drastic price concessions to those optimists who believed there were profits still to be made from this class of ocean carriers Erickson was one of those optimists His purchase of the *Herzogin Cecilie* may be cited as an example of Åland shrewdness He paid $20,000 for this beautiful German ship as she lay in a French port, and within two years received more than the purchase price in freights on Australian wheat and Chilean nitrate

Recently the captain started a service from England to Åland which may add revenue to that procured from hauling Australian wheat After the windjammers unload their grain in Britain they are ready for the last leg of their journey to the home port of Mariehamn, where they may be repaired and refitted for the next journey to the Antipodes in the autumn In order to pay some of the expense of the England-to-Mariehamn journey, their efficient owner conceived the idea of offering passage for the Ålands to tourists The project has been received with considerable success, and each year many people enrich their vacation to the Baltic by traveling there on one of the competitors in the great Australian grain derby (Fig 9)

The advertisements for this service contain some unique information. The vessels can accommodate from eight to a score or more of passengers, who must be able-bodied in order to obtain a ticket Tourists are signed as members of the crew, for strictly speaking the ships are not allowed to take passengers Nevertheless, no duties coincident with sailing the ship are requested from the travelers. No ship's doctor, special steward or stewardess is carried on board, a situation which suggests the stipulation that all would-be tourists must be in good physical condition Another interesting feature of the contract between passenger and company is that the passenger takes all risks of the voyage, signing away any rights for damages from the ship owner in event of accident

Mr Erickson carries no insurance on his vessels, for the expensive rates would

FIG 8. COUNTER-CLOCKWISE WINDS AROUND THE SUBTROPICAL HIGH, SOUTHERN HEMISPHERE COUNTER CLOCKWISE NORTH AND NORTHWEST WINDS AROUND THE SUBTROPICAL HIGH PRESSURE AREA BETWEEN SOUTH AMERICA AND AFRICA MAY AID THE WINDJAMMERS ON THEIR OUTGOING VOYAGE BUT MAY CAUSE DELAY ON THE RETURN TRIP

FIG 9 "L'AVENIR"
THIS BEAUTIFUL MEMBER OF THE SAILING FLEET IS PICTURED AT THE HOME PORT AFTER THE FINISH OF THE 1936 GRAIN RACE

call for a sum almost as high as the initial cost of the ship Hence he chooses to run his own risks Out of twenty or more vessels making the annual grain race, there is an average loss of one a year

Some purchasers of wheat are encouraged to charter the Erickson boats because of the long storage offered by the period of approximately three months required for the wheat cargo to make the voyage from Australia to northwest Europe Moreover, the grain may arrive on the market in May or June, which is later than many of the steam-driven cargoes arrive and still prior to the time of maturity for most northern hemisphere grain Sometimes the May or June arrival gives a definite price advantage

With but little money needed for hiring a crew, with other operating costs at a minimum and with an exceedingly low investment, Captain Erickson can offer a delivery rate for wheat cargo at least two and one-half shillings a ton less than that offered by steamships Moreover, the Erickson ships get considerable cargo by calling at out-of-the-way Australian ports, where steamers offer little competition From some of these ports no railroads reach the interior, no elevators offer storage for the grain, and the cereal is hauled in sacks directly from the farms to the windjammer It is only because of concessions such as lower freight rates and calls "off the beaten path" that Erickson is able to keep his vessels operating How long they will be able to continue no one knows He says, "possibly twenty years" At any rate, wheat is the only commodity which offers much cargo, and if no other commodity can be found to take its place, whenever Australia goes entirely "steamship"—most Australian grain is shipped that way now—the Ålands' windjammers may be dismantled for scrap

SPECTROCHEMICAL ANALYSIS

By Dr A. E RUEHLE

BELL TELEPHONE LABORATORIES

WHEN a substance is heated to incandescence or excited electrically, each of the elements present emits light of wavelengths which are characteristic of that element By analyzing the light emitted with a spectrograph, the nature and amount of the elements present can be found Several thousand chemical determinations are made each year at the Laboratories by this method It is an extremely sensitive method and will detect minute quantities of matter

A sample of the material to be analyzed is heated to incandescence in the cup-shaped electrode of an electric arc whose light then takes on the character of the elements in the unknown substance This light is split by a quartz prism into a spectrum and recorded as lines on a photographic plate The elements present in the sample are identified by comparing the positions of these lines with those of the known lines of the different elements With a spectrograph of good dispersion, any metallic or metalloid element can be detected in a mixture[1] Non-metals require special methods of excitation and the intensity of their spectra varies greatly with the nature of the mixture in which the element is found

The intensity of a spectral line depends on many factors besides the abundance of the element in the source, but the experienced spectroscopist can make a fairly good estimate of the amount of

[1] *Bell Laboratories Record,* May, 1928, p 289

FIG. 1 PHOTOGRAPHING AN ARC SPECTRUM

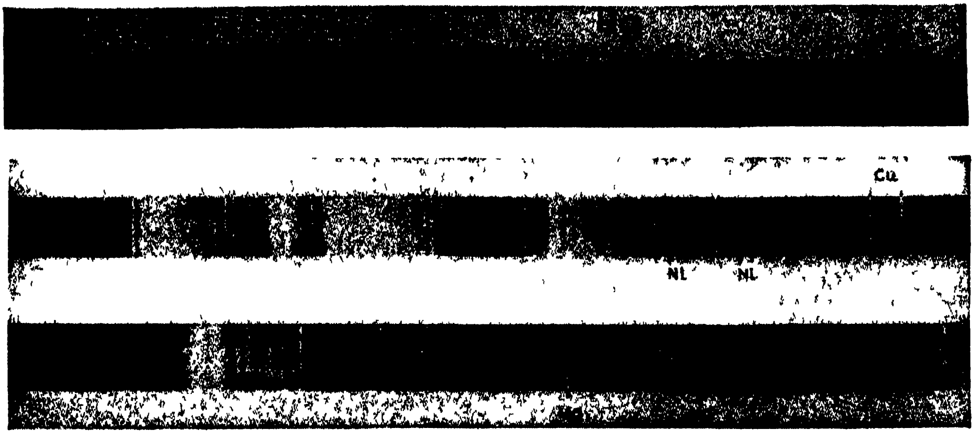

FIG. 2 (ABOVE) DETECTION OF MERCURY AT THE POINT OF FAILURE OF ZINC SUPPORTS FOR AERIAL CABLES. (BELOW) DETECTION OF MINOR COMPONENTS, MAGNESIUM, NICKEL AND COPPER, IN ALUMINUM ALLOYS

each element present. This serves as a convenient guide for a later quantitative determination either by spectrochemical or ordinary methods.

The identification of contact materials is an excellent example of the technique of estimation. It permits finding of what materials a contact is made without removing the instrument from its mounting, without impairing the contact for further use, and without more than momentarily interrupting its service. The surface of the contact is rubbed with a small piece of pure abrasive paper, the paper is burned in a carbon arc and the resulting spectrum photographed. From the lines in this spectrum, which do not appear in that of the abrasive paper alone, the elements which compose the contact can be identified and their proportions estimated (Fig. 3).

The most direct method of quantitative analysis is to compare the spectrum of the sample with the spectra of prepared standards taken under the same conditions and on the same photographic plate (Fig. 4). It is generally difficult to prepare a series of homogeneous solid standards for this purpose. A more practical method is to put the sample in solution and to compare it with standard solutions of known concentration. Measured portions of each solution, dried on graphite electrodes, then serve as the test pieces for the analysis. This general method can be applied directly to a large number of cases without appreciable modification. Difficulties arise only when one or more

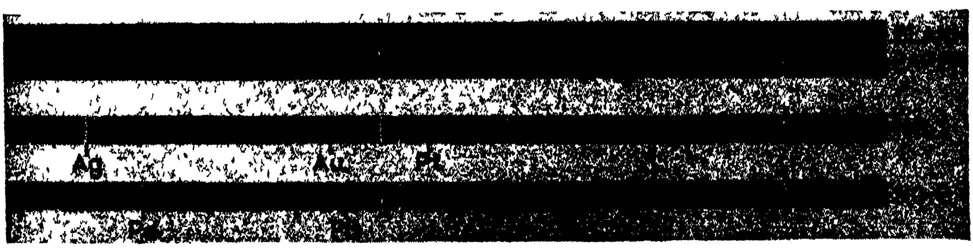

FIG. 3. THE ELEMENTS IN CONTACT ALLOYS CAN BE IDENTIFIED WITHOUT DESTROYING THE CONTACT

components of the sample in question are not readily held in a reasonably concentrated solution By this method the amount of an element present in the sample can be determined to within about 10 per cent

Much progress has been made in devising methods of avoiding the use of standard spectra on every plate for routine work For example, a curve which shows the difference in density of an impurity line and that of a line of some invariant component of a mixture, as the amount of impurity changes, can be used as a reference standard to determine the amount of the impurity in an unknown mixture Changes within reasonable limits in excitation conditions or photographic technique will change the density of both the impurity line and the reference line in the same direction and to the same degree This is called the internal standard method It gives the most precise results yet attained in spectrochemical analysis, but to reach this precision it is necessary to calibrate the response of each photographic plate for different intensities of the spectral lines This is conveniently done by a step-sector as shown in Fig 5 By rotating the sector in front of the slit, spectra are obtained with steps of different density. Plotting from densitometer readings the density of each step of a line against the logarithm of the exposure, i e, the logarithm of the angular apertures of the sector, gives a curve which shows how the density of a line changes with intensity for that plate Since the shape of the curve varies from plate to plate, the difference in density of two lines will not be comparable unless corrected for this variation By taking these factors into account the precision of quantitative determinations has been more than doubled

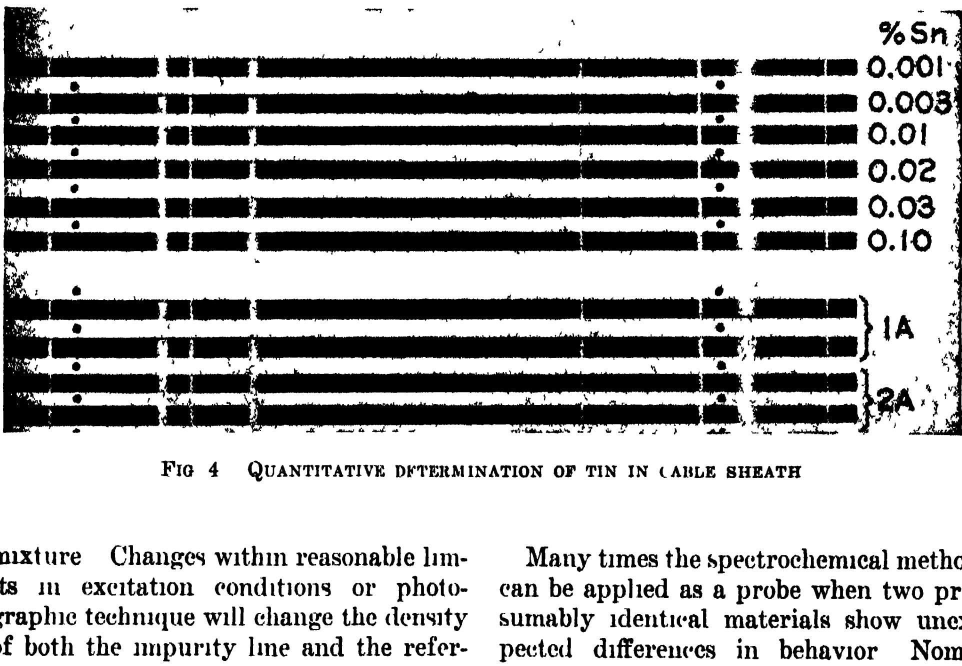

FIG 4 QUANTITATIVE DETERMINATION OF TIN IN CABLE SHEATH

Many times the spectrochemical method can be applied as a probe when two presumably identical materials show unexpected differences in behavior Nominally pure materials are never really pure and may introduce unsuspected impurities which vary with different lots of materials The spectrograph shows differences in composition of the final product and thus often indicates the beneficial or detrimental effect of impurities.

Most spectroscopic analyses are made with emission spectra, but absorption spectra can also be used If light of all

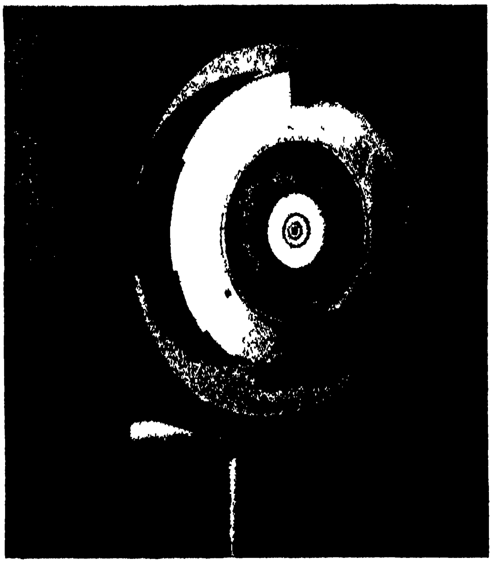

FIG 5 STEP SECTOR WHICH IS ROTATED IN FRONT OF THE SPECTROGRAPH SLIT DURING AN EXPOSURE TO DETERMINE THE EXPOSURE DENSITY CHARACTERISTIC OF THE PHOTOGRAPHIC PLATE FOR LIGHT OF DIFFERENT WAVE LENGTHS

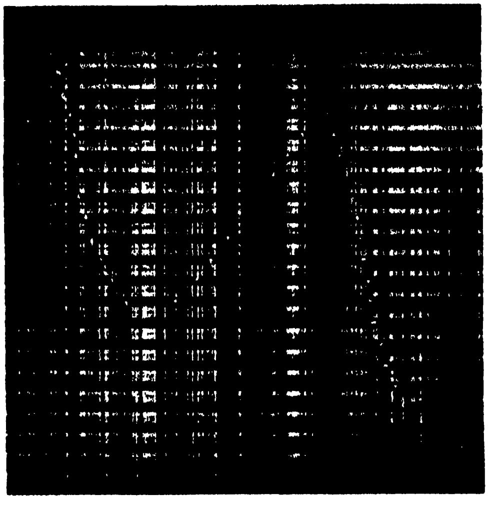

FIG 6 TYPICAL ABSORPTION SPECTRA EXPOSURES ARE MADE IN PAIRS ONE THROUGH THE ABSORPTION MEDIUM AND THE OTHER THROUGH A CALIBRATED DIAPHRAGM BY MAKING A SERIES OF PAIRS WITH DIFFERENT DIAPHRAGM OPENINGS LINES CAN BE MATCHED IN DENSITY AS INDICATED BY THE DOTS

wave-lengths passes through a solution, the amount absorbed will not be the same for all the different wave-lengths; the spectrum of the emergent light will contain bands of different intensities The amount of selective absorption may be used as a measure of the concentration of the dissolved substance (Fig 6). Advantage is taken of this phenomenon in the colorimeter and more specifically in the spectrophotometer, which employ visual matching to determine the amount of absorption In a similar manner the spectrograph and a suitable photometer, used to measure the densities of the absorption spectra plates, find application for this type of analysis Either visible or ultra-violet absorption bands can be used

Another method of analyzing certain types of organic compounds is to measure the intensity of the fluorescent bands

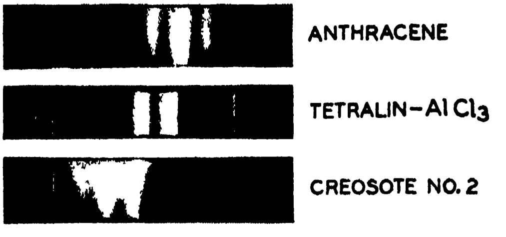

FIG 7. FLUORESCENCE SPECTRA EXCITED BY MERCURY LINES

characteristic of the compound in question (Fig 7) In this case ultra-violet light is used to excite the fluorescent bands and the intensity of the bands is compared with that of the same bands in standard solutions of the same compound

It is only in comparatively recent years that the spectrograph has come into widespread use for quantitative chemical analysis, but it has already proved itself a powerful tool, particularly for quick estimates of composition and where only minute quantities of material are available

METHODS OF USING NATURAL GAS

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NATURAL gas, used sporadically in various oil districts, and usually wasted prodigiously, was not taken seriously as a major fuel in America until long after the World War The huge oil developments of recent years, however, in Texas, Oklahoma and California have now really attracted attention to this beautiful clean fuel While we were sitting up and taking notice, the regrettable practice of wasting gas continued and grew apace. The writer recalls the sight only nine years ago of one field station in California blowing off through a hill-top vent pipe eighty million cubic feet of natural gas daily This waste gas was of just twice the heat value of the fuel which a New York or Massachusetts citizen buys at fifty cents to one dollar per *thousand* cubic feet

The prodigal waste is now being curbed, however, either by law, business sense or common sense The resulting supply thus salvaged has permitted the phenomenal extension of natural gas service which has marked the decade now closing California alone reports 25,000 miles of main high-pressure pipe lines and a consumption of about one billion cubic feet daily Fig 1 shows

FIG 1 HIGH PRESSURE TRANSMISSION LINE, SOUTHERN CALIFORNIA

one of these lengthy and expensive welded steel lines reaching out over a desolate stretch of arid country in the far west. The service north and eastward from Texas and Oklahoma, however, with extensions to Chicago, Detroit and even Philadelphia, raises figures to really astronomical values

With thousands of families deserting coal as a domestic fuel and turning to gas, great concern has long since been expressed over the threat of exhaustion of natural gas Mr. Ralph E Davis, representing the American Gas Association, made a survey of gas resources in 1935 His figures for California, taken for illustration, credited that state with 5,700 billion cubic feet in known reserves

Following this survey about 1,000 billion cubic feet were used in the state during the years 1935, 1936 and 1937 Once again Mr Davis took stock (March 1938) and found 6,900 billion cubic feet available Apparently somebody had discovered a lot of new gas At this rate exhaustion would seem to belong to the somewhat distant future Not everyone, however, shares this optimistic confidence in an indefinite supply of gas and oil Predictions are abroad that only fifteen years of lavish petroleum riches are in prospect We can only hope that the eventual shortage will appear gradually, giving time for appropriate conservation measures

At great terrestrial depths natural gas dissolves freely in its chemical relative, petroleum According to Henry's law, the solubility varies directly with pressure At one or one and one half miles depth, common in modern oil wells, the pressures become enormous, and the concentration of the dissolved gas mounts to high values Relief of this pressure through a well casing will not only force the oil thousands of feet to the surface, but will deliver one, two or even three thousand pounds per square inch at the casing head. The results may be spectacular if intelligent control be not practiced; otherwise the gas evaporates, again in agreement with Henry's law, affording the desired separation of gas from liquid for commercial purposes

Usually natural gas is stripped of a small fraction of valuable light gasoline and of certain ingredients classed as "bottled gas," before long distance transmission A chemical analysis of this stripped gas reveals a decided contrast with corresponding figures for an ordinary artificial domestic gas The following are representative figures, subject to variation in different districts.

	Natural Gas Per cent	(Artificial) Water Gas Per cent
Hydrogen	0 00	36
Carbon monoxide	0 0	32
Methane and other hydrocarbons	98 0	23
Inert gases	2 0	9
Fuel value (in Brit Ther Units)	1,100	550

The fact that the natural fuel is mostly methane, well known as the simplest chemical compound of carbon and hydrogen (CH_4) suggested the metallic carbide theory of original formation Water seeping through fissures in the earth's crust was thus supposed to react with the carbides Carbon from the carbides and hydrogen from the water would yield both methane and petroleum Substantial doubt has been cast upon this hypothesis, however, by the recent discovery that petroleum contains porphyrins, complex organic compounds normally produced by green plants and not available by any stretch of the imagination from metallic carbides The theory of paleobotanists, who point to the vast deposits of diatomaceous earth as evidence, is

accordingly much more in favor. The diatom plant is known to have a rich, oily structure, and it only requires time to account for all of the vast oil resources of western America

The entire absence of *free* gaseous hydrogen, and of carbon monoxide, from the natural fuel has introduced industrial as well as domestic difficulties which have made gas technologists scratch their heads during the past decade These two gaseous substances are of low fuel value per cubic foot, although to be sure hydrogen is of high rating per pound Unfortunately, hydrogen weighs scarcely one eleventh of an ounce per cubic foot

For heating of buildings, or other application where calories, not high temperatures, are in demand, the natural fuel, with its greater intrinsic combustion energy, is obviously superior When high temperature is desired, with cost as a secondary consideration, the artificial fuel is much preferable Free hydrogen burns with great rapidity, and carbon monoxide, a fairly active fuel, seems to be inspired by juxtaposition of hydrogen in the normal domestic artificial gas mixture When natural gas is substituted for artificial gas, the immediate deterioration in flame behavior seems to be of more concern than the less conspicuous gain in mere calories Thus arises trouble

One of the first to protest against natural gas was the scientific glass blower, who was unable to concentrate his flames Methane seems to require about tenfold the burning time needed by hydrogen, and thus needs more space It spreads out in a long "soft" blue flame Such a fire delivered much heat to the room, but would not heat any one spot, such as a weld between glass tubes, to the necessary high temperature The glass blower of Los Angeles, San Francisco and Chicago still has this problem, which he solves either by adding expensive hydrogen gas to his fuel line, or by enrichment of his air blast with pure oxygen Small laboratory Bunsen burners, which handled coal-gas nicely, balked with methane

FIG 3 SPECIMENS OF "GAS SAVERS" WITH OTHER ALLEGED MECHANICAL IMPROVEMENTS WHICH ARE ENTIRELY USELESS.

FIG 2A. OPERATOR TIMING FLOW APPARATUS FOR INTRODUCTION OF ODORANT INTO NATURAL GAS LINES. (2B) HIGH PRESSURE HOLDERS OF NATURAL GAS

The flame continually blew out, since the rate of downward propagation of a methane flame can hardly keep up with the speed of the gas current rising from the burner. Anti-blowout devices now on the market have solved this difficulty.

More subtle difficulties appeared in domestic applications When natural gas was introduced in southern California shortly after the War, the resulting confusion and accidents precipitated a public scandal. The American Gas Association, a non-partisan organization created and supported by gas producers, appliance manufacturers and consumers, proceeded promptly to meet the situation A Pacific coast branch of their excellent research laboratory, home office Cleveland, was established in Los Angeles The combined laboratory force has since developed and effectively introduced a host of reforms in the gas appliance industry

Methane requires so much oxygen for complete reaction that it is often not completely burned in a gas-stove Particularly undesirable is the cut-price domestic heater which is not large enough to handle the gas passed by the control valve It costs an irresponsible manufacturer but a few cents to put a large gas-cock on a ninety-eight-cent heater, but the appliance, unfortunately, does not furnish enough air to the flame; nor does it deliver the air into the gas stream correctly In some cases the flame comes too close to the walls of a skimped combustion chamber.

The result of the incomplete combustion is at least two highly undesirable gaseous products. One of these, formaldehyde, is produced simply by the substitution of only two of the four combined hydrogen atoms of the methane molecule by oxygen from the air. The formaldehyde is, of course, noxious, and gives its own warning in the form of a stale, rank or even pungent atmosphere

More serious than formaldehyde is the carbon monoxide resulting from a slightly better, but not complete burning of the methane This gas is highly poisonous, and has acquired sufficient notoriety in the motor-vehicle field to require no further description

Domestic consumers who are handy with tools frequently make trouble by drilling out the small orifice which restricts the output of a small though well-made gas-heater Such drilling may release two or three times the normal approved gas current Worse yet, it destroys the desirable gas turbulence in the body of the burner. The small gas-mixing chamber will then not provide enough air to afford a safe mixture for combustion and carbon monoxide is the result

Color of flame is no index of presence or absence of carbon monoxide. The presumption that a blue flame is safe is not at all trustworthy Safe yellow flames can be produced, and exceedingly unsafe blue flames are equally common, or *vice versa*

Methane has still further oddities of behavior An easterner, recently arrived in California, became despondent and decided to end it all via the gas route He plugged the keyhole and fireplace chimney, turned on the gas, sank into a chair and awaited the end. After a few hours spent in sleep which he had thought would be his last, he awoke to find himself quite unharmed. He thus confirmed the findings of Tyler and Drury of the University of Southern California medical school that natural gas is entirely nontoxic

Still wondering when the end really was to come, the prospective suicide thought he might as well smoke a last cigarette The results of this experiment might of course have been foreseen. In brief, the unhappy wretch found himself out in the street along with an assortment of lath, plaster and furniture fragments, but still not seriously injured. The whole affair illustrated the fact that natural gas is not only slow-burning, but also relatively slow to explode. By contrast with dynamite, which strikes a quick and shattering blow, the methane mixture, though powerful, was more like the slow-burning powder used to propel large artillery projectiles. One might thus be blown with moderate violence, although with ample reserve power, out into the street, and live to tell the tale.

The fact that methane has neither odor, taste, color nor toxicity renders natural gas too treacherous to be dispensed to the public in the pure state Fig 2a shows the inspection of modern equipment for odorization of the domestic fuel supply. "Calodorant," a mixture of aliphatic organic sulfur compounds, which is suggestive of decayed onions, is introduced to provide a telltale stench It requires only one volume of this aromatic liquid to treat nearly four million volumes of gas Although the odorant itself contains sulfur and therefore produces pungent sulfur dioxide when burned, the amount of the dioxide produced, for example, by an unvented radiant heater or kitchen stove, is far too small to be detected. Actually a bad smell from natural gas appliances which do not leak is proof of faulty construction and is suggestive of dangerous pollution of the atmosphere.

The very low liquefaction temperature of methane places this gas in the small and select group of "permanent" gases. This is a distinct commercial drawback, making it impractical to store and ship the fuel in concentrated form without the prohibitive expense of heavy cylinders like those used with oxygen A compromise is noted, however, in the new type of storage tank shown in Fig 2b Even such facilities do not aid in the problem of shipping natural gas to smaller towns too distant from the gas-fields to warrant installation of expensive welded steel pipe lines

These observations direct attention

once more to the hydrocarbon material "stripped" from natural gas before delivery to trunk pipe lines. Such material contains a few per cent. of the slightly heavier hydrocarbons propane (boiling point −45° C.) and the two forms of butane (−11° to +1°). These excellent fuels are readily liquefied under moderate pressure, and in such condensed form are finding wide application as "bottled gas." Country homes, small-town gas systems, mountain cabins, auto road camps and even buses and trucks are finding the bottled product a great improvement over obsolete gasoline appliances, especially the old gasoline stove It should be noted that these bottled gases are of two to three times the heat value per cubic foot of methane, and special adjustment of appliances is essential.

Like model-T Ford cars, the natural gas-stove has been the victim of numerous accessory promoters. Specimens of "gas savers" and other alleged mechanical improvements are shown in Fig. 3. These devices are emphatically condemned in unanimous chorus not only by gas companies, but more pointedly by the Association If not actually a fire hazard, the "gas saver" is usually a generator of carbon monoxide, and at best is entirely useless.

WE GROW OLD

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THERE is much to learn from certain individuals who grow old slowly and gracefully. One of these was Dr Charlotte Marie Davenport, well known a generation ago She was born in St Petersburg, Russia, apparently in 1825, but there is no official record of her birth She died in St Louis in 1936 at the reputed age of 111 years.

Married three times, at the ages of 16, 18 and 69, she bore 11 sons. Shortly before her death, to the best of her knowledge, all were alive and well. The eldest was living and 93 years old Her third marriage was to William Davenport, a man of 21 working on the *Times* in London They lived together happily for 40 years.

She traveled widely In Tahiti she spent a month with her good friend, Robert Louis Stevenson In England she gave lessons in physical culture to the late Queen Alexandra She was photographed with Sarah Bernhardt Coming to the United States, stacks of newspaper clippings, yellowed with age, bear witness to her reception by New York's "Four Hundred" She was interviewed in 1889 by a young reporter on the *Marion Star*, who later became President of the United States, and whose account is available for all to read Among her pupils was Mrs Phoebe Randolph Hearst, mother of the famous publisher According to society reporters, she taught Mrs. Alice Lee Longworth how to hold a cigarette properly She was an intimate friend of Admiral and Mrs. Dewey and of Joseph Pulitzer of St. Louis

To give in a few words a picture of her life is impossible Though some of her activities can not be proved, owing to the great lapse of time and their spread throughout the world, enough of them have been checked to lend credence to the whole.

This wonderful woman was an outstanding example of a small number of persons found in every race and in every country who do not appear to age like ordinary mortals, or else are relatively immune to disease and who do not wear out Thus, Thomas Edison lived to be nearly 90 and did much of his best work between 70 and 80. Elihu Root, one of our greatest statesmen, lived a little more than 98 years Titian died after he had attained his 99th year and he painted his masterpiece at the age of 85 Great age is not always coincident with intense activity and productiveness Sometimes it is associated with placidity, with minds free from worry. In this connection we recall the statement—interesting if true—that there are more centenarians among the colored than the white population of the United States, though the absolute number of colored people is only one tenth as great What the secret of long life is we obviously do not know. A correlated physical and psychological study of a selected group of individuals over 90 years of age is long overdue

On the other side of the picture are those who grow old before their time. We need to know why. The processes of aging do not operate uniformly. The great difference in years between postponed aging and early aging is evidence that in nature there are some factors which modify the speed of the changes that occur. This gives us some reason to hope that eventually mankind may be able to modify intentionally the processes of aging, if only to a small degree.

The first step in distinguishing between aging and disease has hardly been taken. It is a very difficult step to take Some

hold that arteriosclerosis is a manifestation of senescence which occurs particularly early in some persons Others maintain that it should be considered as a disease and believe that hope may therefore be entertained for prevention and treatment. Whichever the truth may be, the conclusion is not justified that the outlook is hopeless even if arteriosclerosis is really a function of senescence, for it may prove as possible to avoid premature aging of the arteries as to prevent a disease of the arteries [1]

For the purpose of this discussion we regard disease as the effect of injury, however inflicted, whether by pathogenic organisms, malnutrition, excessive strain or something else. Life itself is a succession of adjustments between the individual and his environment and also between his own component organs and tissues Some of these adjustments are easily made Like all vital activities, the ability to make them is maintained by use Other adjustments may be only partial and may leave the individual handicapped by depletion of reserves. Some of the processes of aging are hastened or modified by disease Consequently, one way to prolong life is to protect the organism against injury This, after all, is what has actually increased the expectation of life in our time It is a matter of avoiding complications that accelerate or alter the processes of aging.

Were it not for disease it is evident that some systems could, if self-sustaining, function beyond the life of the body as a whole Friedenwald thinks the possible length of useful life of the visual apparatus is at least 120 to 130 years. Ivy remarks that the digestive tract, when not locally altered by disease, is capable, in most elderly people, of serving beyond the ordinary duration of life Since there are also tissues whose life, useful or otherwise, is less than that of the whole body, it is obvious that aging may be hurried as well as delayed. For instance, Krumbhaar points out that the involution, or aging, of the thymus gland begins at about the age of puberty and proceeds rapidly to an advanced stage in adults Tonsils of patients over 50 or 60 are but a slender source of income to otolaryngologists because they have become senile and shriveled Aging of the genital system precedes generalized senility Not only do the processes of aging differ in rate, but, in addition, many of them are interdependent, so that we must think in multifunctional relationships We can not isolate a single aging process in "pure culture" and study it alone

Within the body the aging processes operate in many different environments. It has been estimated by Krogh that the vascular capillary endothelial surface amounts in each one of us to about 6,300 square meters In other words, it is equal to the surface of a plot of ground about an acre and a half in extent. There are certain well-established regional differences in permeability, and in any area temporary variations may occur Consequently, the exchange between the blood stream and the extravascular fluids is not uniform The tissue fluids of avascular tissue (cornea, epidermis, cartilage, etc) are more withdrawn from this great sheet of endothelium and of blood supply than those possessed of a rich capillary network Diversity in activity of cells in different tissue fluid environments is not likely to be without influence

[1] It is interesting that the Josiah Macy, Jr, Foundation passed from a survey of the problem of arteriosclerosis to an equally detailed study of aging from the biological and medical points of view. Twenty three investigators, drawn from many specialties, cooperated in the first (Macmillan, 1933), and twenty-five in the second (Williams and Wilkins, 1939) The Union of American Biological Societies and the National Research Council, together, sponsored a conference on aging held at Woods Hole in the summer of 1937 for which provision was made by the Foundation A committee of the council has been actively at work for several years trying to foster research

We think at once of differences in fluid consistency, hydrogen ion concentration, mucins, mineral salts, polysaccharides and hormones. Local factors may obviously accelerate, retard or modify the processes of aging. Therefore, we have to look through the screen of disease, identify the aging processes as clearly as possible and search for clues by noting their behavior in different environments

Decrease in *water content* is perhaps the most fundamental of all aging processes The individual shrinks both in weight and in stature The latter must be taken into consideration when we compare our height with that of our grown-up children In general, they are conspicuously taller, but many of us are a little shorter than we were at their age Probably not unrelated to this progressive dehydration is granulation or *condensation of colloids* The capacity of a newly formed, or young, colloidal gel to bind water decreases with age With loss of water the dispersion of the colloidal particles becomes less, and elasticity and flexibility decrease This phenomenon accounts for the aging of elastic colloidal fibers in the walls of blood-vessels H Gideon Wells is of the opinion that arteriosclerosis depends primarily on changes in the elastic tissue that reduce its resiliency and lead to arterial dilatations Others do not agree, but the ancient dictum that man is as old as his arteries and the importance of the "vital rubber" are not lessened by recent investigations The loss of elasticity and breaking up of red blood cells is in all likelihood a similar phenomenon Indeed, we are only beginning to appreciate how wide-spread the aging of colloids may be in the body and how different in different tissue fluid environments

Decrease in *replacement* of tissues is another change that comes with aging In a 60-year-old man a wound takes five times as long to heal as a wound of the same size in a 10-year-old child (du Nouy) Replacement depends on ability to form new cells from old ones. Fibroblasts and capillary endothelial cells seem to retain this property as long as they live, or nearly so, whereas nerve cells are among the first to lose it.

We have spoken about the unequal longevity of systems and tissues. Carrying the analysis farther, we need more light in the relative life span of cell types The urge to replacement will also have to be determined, for this may depend upon the physiological reserves. This line of investigation is essential, but will be tedious because the frequency of cell division will have to be computed It will be heavy spade work.

It is common knowledge that after maturity *adaptability* decreases with age. An old person adapts himself less quickly and effectively than a young adult to heat or to cold or to an onrushing motor car There is a depression in adaptability to almost all changes, whether of external or internal origin. Basic perhaps is a curious kind of faltering or indecision in regulation Cannon has shown that with aging the homeostatic mechanisms become more and more restricted in their ability to maintain the essential stability of the blood We need to dig deeper and to unearth the aging processes responsible for this restriction

Very fundamental are hereditary factors Not all individuals approach old age equally endowed Operation of these hereditary factors is often masked, as are the normal processes of aging, by the added complication of disease and accident The difference is that the hereditary factors are spread equally throughout all the cells of the body (except the sex cells) though response is limited

These purely physical, chemical and biologic mechanisms of aging are just beginning to be studied There are vast fields as yet totally unexplored Nearly equal is our ignorance of the psychiatric, emotional and sociological aspects of aging

Few people anticipate growing old with any particular relish Some strive against it with all their might and main. What do they fear? In many cases it is not death that they dread. They see their friends drop off one by one. They write more and more letters of condolence until the task becomes almost mechanical—an unpleasant duty. They know that death is inevitable, and some of them even court it as a delivery from unhappy situations. As G Stanley Hall said, "to have once deliberately oriented ourselves to death before our powers fail gives us a new poise, whatever attitude toward it such contemplation leads us to " This is sound common sense.

Lewellys Barker reminds us that only rarely do old people know, when on their death beds, that they are about to die Sir William Osler made a careful study of the modes of death and the sensations of the dying in the case of some 500 persons. He stated that about 90 of the 500 suffered bodily pain or distress, 11 showed mental apprehension, 2 were positively terrified, 1 expressed spiritual exaltation and 1 suffered from bitter remorse. But, he continued· "the great majority gave no sign one way or the other; like their birth, their death was a sleep and a forgetting."

To fear pain, however, is only natural Pain cries aloud for relief, and in old age powers of adjustment and recovery wane. It is scant comfort to be assured that sensibility to pain decreases in extreme old age, though it seems to be a fact. A realistic attitude is indicated Looking ahead from the age of 60, the percentage of chances of death from different causes, according to the 1930 U S. Census, are as given in Table 1

TABLE 1

	Male	Female
Cardiovascular renal diseases	59 85	59 58
Cancer	10 71	11 00
Accidents	4 53	4 55
Influenza and pneumonia	6 55	7 28
Tuberculosis	1 75	1 34
Diabetes	1 74	2 91
Other causes	14 87	12 44

On adding the first two items together, we find that almost three in every four individuals of 60 will die from cardiovascular-renal disease or from cancer. Much can be done by prevention, early diagnosis and treatment. Yet how common is the attitude "where ignorance is bliss 'tis folly to be wise." Millions, however, suffer despite reasonable precautions. I am confident that in the future social order a perfectly proper and legal way out will be found for those who are incurably sick and racked with pain To prolong their suffering is, like war, a misuse of science. Just at present we remain, in this respect, in the Dark Ages

But what a great many old people fear more than death or illness are long years of uselessness, living on the bounty of their relatives and friends. In short, they see the walls closing in on them, and they doubt their ability to adjust themselves to the changing conditions. The prospect is really not so gloomy, provided medical science marches on and continues to relieve inevitable aging from the complicating handicap of disease. We may not agree with Browning:

> Grow old along with me;
> The best is yet to be;
> The last for which the first was made

But there are even now some advantages for the healthy among the aged. Emerson has said that· "At fifty years, 'tis said, afflicted citizens lose their sick-headaches", and "'tis certain that the graver headaches and heartaches are lulled once for all, as we come up with certain goals of time The passions have answered their purpose; that slight but dread overweight, with which, in each instance, Nature secures the execution of her aim, drops off. To keep man on the planet, she imparts the terror of death To perfect the commissariat, she implants in each a certain capacity to get the supply, and a little oversupply, of his wants To secure the existence of the race she reinforces the sexual instinct,

at the risk of disorder, grief and pain. To secure strength, she implants cruel hunger and thirst, which so easily overdo their office, and invite disease. But these temporary stays and shifts for the protection of the young animal are shed as fast as they are replaced by the nobler virtues."

That relief from many responsibilities does pave the way for continued usefulness is sure With aging there is an increase in conservatism Hasty decisions are not so frequent Long experience gives perspective, and interest has a marked tendency to expand to the city, the nation and the whole world Activities which do not demand great physical effort can be carried on without impairment, and more leisure time is usually enjoyed. How can these and other assets be put to the best possible use?

The first essential is to plan in advance for old age As a rule the only effort which men and a few women make is to save enough money to provide for their old age. They suffer the greatest shock of their lives when they are pensioned off or are discharged to make places for younger persons They have not cultivated any useful activities to take the place of those of which they have been suddenly deprived They soon realize how crushing is inactivity For most women it is a little different The majority have their home and children to look after Since the children leave one by one, the transition is gradual and home cares remain to some extent A plausible case can be made out for the average longer life of women on the basis of the relative absence of this sudden demand for adjustment

How can we best make this running start which will carry us over this great change in our lives? We must both seek help and help ourselves Great assistance can be obtained from the psychiatrists, who study personality and its adjustment. In the modern world old-age guidance is needed as well as child guidance. Help is also to be secured from others who have made the adjustment satisfactorily. Such people are beacon lights in every community It is for them, at our urgent request, out of their wisdom and experience to tell us how they do it. This is not the least of the many significant contributions to society that they can make. With real vision Barker says that "The psychology of normal old age is probably never very well understood except by those who, remaining healthy, live to be old themselves." The trouble is that these leaders extend the helping hand not to their immediate followers, who need it most, but to the rising tide of starry-eyed children.

After all, as we grow old, self-help is the mainstay. There is no denying the fact that in some ways we become as little children before we pass on Little children prattle on and on and nobody pays much attention. With increasing age there is a growing tendency to talk too much The feeling of inadequacy grows, as less and less notice is taken of what the elders say. Compensation urges them to talk more and offer gratuitous advice Advice falling on stony ground brings forth little fruit, but when it falls on receptive ground it develops without insistence by the sower.

Except for disease, this feeling of inadequacy is the heaviest burden that the aged bear The most effective preparation for advanced years is cultivation of some line of activity which can be carried on as we become more and more physically feeble. The really happy aged person holds his head high and consequently avoids a feeling of inadequacy because he or she is able to do something extremely well. It makes very little difference what this something is as long as its value is appreciated by others. To compensate for necessary restriction of activity, specialization is clearly indicated And the beginning must be made before the handicap of years is felt

The social *magna charta* of the aging

individual and of all mankind has been written by John Dewey in the following words, " . . I am unable to see how the basic human problem can be solved without social changes which ensure first to every individual the continued chance to have intrinsically worth-while experience and secondly provide significant socially useful outlets for the maturity and wisdom gained by experience " It is up to the community to provide this chance or opportunity, but the individual must not be passive On the contrary, he must actively seek the opportunity, not only for himself but for others, because service does not necessarily cease with old age, but is, or should be, co-extensive with life

In the days of Washington and Jefferson, when the nation was born, the average age of white persons in this country was little more than half of what it is to-day The increasing life expectancy of the nation is dramatic, as shown in Table 2

TABLE 2

1789	New Hampshire and Massachusetts	35 5 years
1850	Massachusetts	40 "
1900	United States	50 "
1920	United States	55 "
1930	United States a little over	60 "
	Possible in near future (Dublin)	70 "
	Maximum (Dublin) .	75 "

Life expectancy is the average number of years that babies born in a particular year will live, provided the mortality rate remains the same during their lives as that calculated for the year of their birth The life expectancy has progressively increased as a result of decrease in the mortality rate, and probably has not yet reached its peak

Let us now take up the alterations that have occurred, and are likely to occur, in the percentage of different age groups in the total population of the United States Table 3 is based on investigations by Dr. Louis I Dublin

TABLE 3

Year	Ages 0–4 Per cent.	Ages 5–19 Per cent	Ages 20–44 Per cent.	Ages 45–64 Per cent	Ages 65+ Per cent
1850 .	15	37	35	10	3
1870 .	14	36	35	12	3
1890	12	34	37	13	4
1910 .	11	31	39	15	4
1930	9	30	38	18	5

It follows from the figures in the first column of Table 3 that there has been a steady and rapid decline in the relative number of children under five years of age, the percentage having decreased since 1850 to almost half its value No less interesting and important is the fact that the relative number of persons exceeding 65 years has almost doubled in the same interval, while the percentage of the population in the productive years 20–44 has remained about the same It is chiefly this group that must provide care for the decreasing number of young and the increasing number of old people

Dublin mentions the possibility that the standards of living may fall, owing to the increasing burden on people in the productive ages But we must not forget the changed status of women. In the past 50 years it is said that the percentage of gainfully employed women has increased from 14 5 to 22, and the end is not yet This means that the strain on this age group is being relieved because the burden no longer falls almost wholly on the approximately 50 per cent of males in it

The age 20 to 44 is the age level of active employment, but productive labor is carried on by some older as well as by some younger persons However, the relative number of older workers, though increasing absolutely owing to the change in population structure, is being decreased by earlier retirement, and the relative number of the younger workers is being decreased by child labor legislation and a greater number of years devoted to education. This bearing down upon the productive age group

by the elders above and the bearing up by the young below, so that the production group is caught between two millstones, does not at first sight appear to be a great disadvantage, because, owing to improvements in means of production, fewer workers are needed

Already, however, the strain upon those who are employed is increasing because the unemployed, as well as their juniors and seniors, must be cared for The juniors are decreasing slightly in relative number, but our ideas are more extravagant than those of our parents as to what children should have The crop of palatial public school buildings rising throughout the land bears witness to this change The dwindling band of producers must pay the piper for youth It must also provide old-age benefits for an actually increasing number of aged Legislation is passed not so much by inviting the votes of the aged as by suggesting to the producers that they, individually, may wish to be relieved of responsibility by "passing the buck" to the government To obtain "social security" the industries, which employ labor, are taxed almost to the point of extinguished profits

Certainly the situation is already unbalanced It involves conflict of interest between producers and consumers The first, as we have intimated, are in the minority and must serve not only themselves but all the rest To partly compensate for this handicap, the New Deal protects the producer (farmers and others) by causing an artificial scarcity and by thus raising the price level of their products at the expense of the larger class of consumers Among the consumers are many unable to pay higher prices for needed food and clothing These suffer because efforts to increase their purchasing power by unprecedented government spending have not in general been successful Money has not made its way into the right pockets The results of a Gallup Survey (*Globe-Democrat*, April 2, 1939) show that half of town and city dwellers are already on relief or near it The state, in turn, derives its funds from the hard-worked producers, and the vicious cycle is complete

The rise in age level of the population not only increases the strain on the small band of producers but also brings about a shift in character of production. As an example of necessary adjustments in an aging population, wise shoemakers will not blame the New Deal because the sales of children's shoes fall off by the million, rather will they pay increasing attention to the manufacture of shoes suited to older people

In respect to health services, increase in length of life intensifies certain problems Curiously enough, the pediatricians are among those most interested It is doubtful whether they have yet felt the decrease in number of children because the service per child is increasing Although children are obviously given better medical care than ever before, there is still much room for improvement The 1930 census revealed fewer children under five than the previous census, and, what is even more significant, fewer under five than in the next group of five to nine years In other words, the supply of children was even then falling off. Later, in 1938, there were, according to Fairchild, more than 1,600,000 fewer children under ten than five years earlier Already there is a noticeable decrease in the number of young children entering many public schools

Cases of those diseases to which people over 45 are heir are increasing as they themselves increase in relative numbers Thus, in the age group from 80 to 89, inclusive, 66 per cent of males died of cardiovascular renal diseases and 64 3 per cent of the females The deaths from cancer reached their peak at 22 4 per cent for females aged from 50 to 59, and at 13 4 per cent for males aged from 60 to 69 More important, however, is

the mental care of the aged. They require expert guidance just as truly as children do Maladjustment, or lack of compensation by new activities for the giving up of others to which they were accustomed, is, as we have said, the main burden of the aged. The state of mind which this maladjustment engenders is not without harmful influence on whole families.

At present the number of persons over 65 relative to the total population has approximately doubled since the Civil War. Obviously, this change has brought about a profound difference in family life—twice as many father-in-laws and mother-in-laws to be given useful work in the home And the numbers of the latter are increasing more rapidly than of the former, for a majority of old people will be women, because female mortality for the aged is considerably lower than that of males The increase in the percentage of aged people, coupled with the realization that they are still potentially very useful members of the community, will inevitably but gradually bring into being a new group of specialists in medicine—the geriatrists A thorough knowledge of internal medicine plus a lively interest in personality and its problems will be necessary for these specialists The mental aspect of treatment of the aged looms large Only when there is a demand for it, will appropriate training be provided in the medical schools. The dictum that "The boy is not a little man" is true, for he differs functionally and structurally from a man, not merely in size. An old man is not simply an unwanted adult. He differs as much from a person in his prime as a boy does, but in ways that we do not yet fully understand

In education, also, the social order will have to become adjusted to the needs of an increasing fraction of the population We have mentioned the shrinkage in numbers of young school children. We have seen adult education come of age. It is only a matter of time before farsighted book publishers will make a careful study of the tastes and needs of older people and cater to them With age there usually comes more leisure and time to read. As consumers of books, they are to be reckoned with And, perhaps, some leading university will recognize the fact that persons past middle age still wish to keep abreast of the times

In the shaping of national character the progressive alteration in population structure is certainly not without influence We can not expect our nation to-day to behave in the same way that it did at the time of the Revolution. Dublin, looking to the future, remarks that "conservatism may become much more characteristic of our thinking than it is to-day There may be expected fewer radical departures from accustomed ways and suggestions for new forms in all phases of life will probably meet with increasing resistance" Dewey has discussed this matter rather fully He writes " . conservatism increases with age, so that in the degree in which the older group expresses itself politically we have the curious and indeed ironic condition that at just the time when measures of social readjustment are most needed, there is an increasing number of those whose habits of mind and action incline them to resist policies of social readjustment " However, it is open to argument whether this condition is not so much "ironic" as fortunate. Recent history seems to demonstrate that the greatest danger in social readjustment is, as on the highways, the rate of speed To Dewey's reminder of the prospect of one third of the population over 50 years of age, we counter with the statement that according to the best available statistics the safest age for driving a motor car is fifty In my opinion, the rising age level is a blessing because experience teaches, and it will supply a brake.

THE ROLE OF THE FUNDAMENTAL SCIENCES IN MEDICAL PROGRESS

By Dr. ANTON J. CARLSON

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THE mysteries of the starry heavens and the urgencies of human pain seem to have made man pause and ponder at the very dawn of reason. At any rate, the earliest accounts we now have of man trying to understand himself and the universe deal with astronomy and with human sickness Medicine is sometimes spoken of as the mother of the sciences The earliest, sporadic achievements in medicine here and there among the peoples of the earth, such as the use of quinine against malaria by the South American Indians, the use of toad skin for dropsy and vaccination against smallpox by the Chinese several hundred years before Jenner, were steps in the control of rather than in the understanding of disease The Greeks had Galen, and Galen was on the right road, but he had few real followers for a thousand years Hence, medicine in the sense of discovering the causes and working out the means of controlling and preventing human ills dates back only a few hundred years And the ascending curve of achievements in medicine closely parallels the progress in the fundamental sciences of biology, chemistry and physics This is not an accidental parallel, as we shall see Nor is the parallel explained entirely by the fact that all science is one in method, and the human brain is the catalyzer of them all The reason is: Biology, chemistry and physics have furnished and will continue to provide many of the data, the hypotheses and the tools necessary for the next step in the unending fight against disease.

Which are the "fundamental sciences" and what are their rôles in medical education and medical practice? Human anatomy, animal physiology, biochemistry, bacteriology and pharmacology are historically the legitimate offsprings of medicine, and these sciences still dwell largely on the old paternal homestead Perhaps it would be more correct to call biochemistry an adopted child, adopted from chemistry. They are now an integral part of modern medical education, medical practice, medical research, hence included in the term medicine But human or animal physiology, at least, is as important in our secondary and college education as it is in medical education We are slowly realizing that at all stages of education the traditional "three R's" must be rounded out with an "H," which stands for, not hallelujah, but *Health* And health education is more than the establishment of so-called health habits, like love for the tooth-brush, fear and hatred for gin and whisky. Education is more than habit formation, more than cerebral canalization to the centers for love and hate Education means understanding Health education means understanding the living body, the living machinery of man, the known causes of disease or ill health and the known ways of keeping fit This is the contribution of the medical sciences to primary and general education in our democracy, as yet only partially either sensed or achieved The imparting of the traditional three R's to youth is by the nature of the case largely a matter of dogma and drill But drill and dogma are largely futile in health education Health education can not be achieved by the memory route, as can the alphabet, the multiplication table or the church catechism Health education involves the

ABC's of science and the scientific method, both on the part of the teacher and the pupil, that is, controlled experimentation, rechecked observation, repeatedly verified cause and effect relations It is the development of the skill in finding "facts," the use of reason based on facts rather than an exercise of faith based on unverified dogma

Botany What about the other biological sciences, botany, zoology, and the union of these two, with a sprinkling of geology, and climatology, and constantly implemented by chemistry, namely, agriculture? Do these play any rôle in modern medicine? Those who look no deeper than to the surface of things may say that the potato and the pine are so different from man, the self-styled "crown of creation," that the scientists who deal with the former can not possibly produce anything of importance to human medicine Let us pause and see In the first place, the plant groups Bacteria and fungi are common agents of debilitating and deadly human disease But more fundamental still. The essential machinery of reproduction, growth, nutrition, respiration, heredity and death is the same in the plant as in man The plant is subject to disease and death, much as man, from defective heredity, malnutrition, poisons, bacteria, animal parasites and viruses Plants take up from the soil and concentrate in their seed and other structures substances toxic to man, such as selenium and fluorine Man secures much of his food from the plant kingdom, and the quality of that food (for example, vitamins, iodine, iron, the nature of the proteins, etc) is of great significance to human health Many significant medicines, like quinine, ephedrin and digitalis, are manufactured by the plants But, perhaps, it is in the studies in cell life, on the machinery of heredity and on the mechanisms of immunity to disease in plants that the science of botany attains its greatest significance to human medicine So the botanist is more than a "fellow traveler" to the physician; he is a fellow worker, that is, if the botanist will have it so We who labor in the field of human and animal health and disease have for fifty years been greatly puzzled by the seemingly abrupt and adult appearance of the complicated hormone machinery, specifically beginning with the vertebrates The riddle has been solved for us in the last ten years, at least in part, by the plant physiologist Many of these hormones are present and working in the tissues of the plant In the vertebrates their production has become confined to specific organs or glands It is no longer so perplexing to find that the pussy-willow produces chemical messengers not so different from those produced by the ovaries of women and the testes of men

Zoology It is true, man can get tuberculosis and undulant fever from the cow and the goat, trichinosis from the hog, deadly glanders from the horse, Asiatic plague from the gopher and the rat, tularemia from the lowly rabbit, tapeworm from the fish, spotted fever from the wood-tick, malaria and yellow fever from the mosquito, typhus from the louse and deadly fever from the parrot, and this is just the beginning, not the end of the list But these are not the things that make zoology so important to medical advance The significance of zoology to medicine can be sensed, even by intelligent laymen, in the following facts

(1) The fundamental identity of body structure and body machinery in man and animals

(2) The essential identity of the machinery of heredity in man and in animals, and the importance of heredity in the susceptibility to disease, in the stability of the mind, in growth and longevity, etc , of man

(3) The frequent appearance of spontaneous diseases in animals, such as infec-

tions, cancer, dietary deficiencies, liver, heart and arterial diseases, brain and body failings in the aging process, etc

(4) Experimental diseases, such as infections, the numerous and important dietary deficiency diseases, diseases due to deficiency or excess of the hormones in the body can be induced in the animals, domestic and wild

(5) It is safer and faster to standardize new and old drugs on animals rather than on man

The significance of these five zoological categories to progress in medicine are almost self-evident Man is an animal Some people believe, others hope, he is also something more At times man behaves as if he were something less There may still be some uncertainty both as to facts and factors in biologic evolution, but the essential identity, in health and in disease, of the brain, the heart, the gut, the lungs, the liver and the kidneys of man and the animals is as certain as the product of two times two Unfortunately, we do not transmit our own understanding and knowledge with our germ-plasm We can give our children only the capacity and the facilities to learn No matter how great our medical knowledge to-day, our children of to-morrow start exactly at zero So each generation of medical students must secure its fundamental training in the nature of health and the nature and control of disease on the animal, living and dead History tells us that whenever we succeed in reproducing a baffling human disease in the experimental animal we start to go places, and go fast The fundamental experiment of the immortal Pasteur was on sheep, not on men Some serious human ailments can, at present, not be diagnosed with certainty without resorting to tests on living animals The mouse and the rat, the guinea pig, the dog and the monkey are necessary material in the modern medical school, the modern hospital, the modern medical research institute Here I pause to remark that all these agencies of medical progress in these United States to-day find themselves hampered by inadequate animal quarters for medical teaching, medical research and medical service to man Even the wisest medical statesman could not foresee the expanding needs of this type of medical aids for to-morrow Every unit of the commonwealth—city, county, state and nation—must nurture, not hamper, this important avenue of medical advance, the use of animals in medical education and medical research

Psychology has succeeded in cracking its confining carapace, traditional philosophy, and as a biologic science has rendered and will render great service to medicine in the direction of understanding man, both in health and in disease

Paleontology and *Anthropology* may shed light on the antiquity of disease These same sciences may some day tell us how long ago our ancestors were something less than apes, and hence how long the road ahead till we, their children, shall have earned the name *Homo sapiens*

Preventive Medicine is the natural child of fundamental medical research and social statesmanship If in many medical schools this child is anemic, it mainly is due to lack of medico-social statesmanship As regards a really comprehensive and effective disease-preventing program for all the people, some progress is being made with smallpox, typhoid fever, malaria, tuberculosis, syphilis, dietary deficiencies, etc But by and large, the perplexities confronting the students of nation-wide disease prevention to-day seem as discouraging as did the control and the cure of individual sickness to the doctor of a hundred years ago Ignorance, irresponsibility, poverty and greed are formidable obstacles to the health of the individual Nation-wide, these seem insurmountable,

except to the few of us who may be killed but never conquered. But the physician alone can not win this war, nor can it be won without him This program involves the regulation of industry by the needs of health Above all, it involves a very high level of education and sense of social responsibility on the part of every citizen It will not be achieved by law or force. If and when it comes, it will be by the action of free men, based on understanding It involves adequate food production (hence *agriculture*) and distribution (hence *commerce*), adequate housing, adequate work for all who can and will strive, and the sterilization of those who can not or will not do their share of the world's labor.

Chemistry We have volumes on the role of *chemistry* in medicine, and I have a feeling of mental paralysis, not because of paucity but by the very abundance of material and illustrations Man is a chemical and physical machine Some like to think he is more than that Maybe so Some day, when we know more about chemistry and physics, we may actually know. But that the same chemical substances and chemical energies operate in man as in the rest of the universe is now abundantly proven We owe to chemistry many of the methods necessary in the isolation, analysis and comprehension of the processes of health, as well as disease, in the identification of chemicals that cause disease, in the manufacture and purification of chemicals that aid both in the prevention and in the cure of disease The microscope revealed the cell as the present unit of life, but it remained for chemistry to reveal its composition and its energetics. Just picture to yourself where the physician and his patient would be to-day, without our present knowledge of the chemistry of respiration, of foods and digestion, of blood and urine, of growth, of hormones, of bacterial toxins and immune bodies, of such important remedies as insulin, arsphenamine, sulfanilamid and vitamins Several hundred years ago the brilliant but erratic Paracelsus said· "The true use of chemistry is not to make gold but to make medicines" To-day we would say· The true use of chemistry is not to make gold, not even to make medicines, but to aid man in the understanding of his own life and the universe about him

Physics To-day the line separating chemistry from physics is very faint, indeed. These two sciences unite in probing the atom, in harnessing the electron. All life processes in health and in disease involve or consist in chemical change, and every chemical change has physical concomitants The human eye, the human ear are in fact physical machines, worked by the physical forces of light and sound The discovery of electrical energy did more for biology and medicine than it did for industry For millions of years there has been going on in all living things an adjustment to such physical factors in the environment as barometric pressure, oxygen concentration, humidity, heat, light And there is no good reason to think that this is the end of the list Where would medicine be to-day without the microscope? The x-ray form of physical energy discovered just a minute ago, considering man's terrestrial time, is very nearly as essential in the diagnosis of gastric ulcer, tuberculosis of lung and bone, tumors, rickets, brain abnormalities, diseases of the gall bladder, the kidneys, the heart and the blood vessels Physiotherapy is in its infancy. In our present scanty understanding of cancer, x-ray and radium are helpful aids in its control. The ingenious contrivances given us by the physicists who perfected the radio have yielded a new method for studying disorders of the brain. We need say no more. If these examples are not convincing that advances in chemistry and in physics constitute the very air, water

and food requisite for advance in medicine, I might as well save my time and yours. A few years ago an able physicist told me that in his opinion all physicists should abandon their research in pure physics, and for the next generation focus their brains and skill on biology and medicine. In my humble opinion, that would be a great mistake. Let a Compton and a Millikan continue to capture and dissect the elusive cosmic ray, from the top of the stratosphere to the bottom of the ocean In the long run, that will be of greater service to medicine than if such men, almost innocent of biology, should turn their attention to cancer. We need more, not less, brains in every science

But the chemist and the physicist have an easier task than the physician In their dealings with atoms and energy, they are the least hampered by the human equations of ignorance, superstitions and misunderstandings of their fellow men Not so the doctor When he tries to protect children against smallpox or tries to get an understanding of the maiming and killing disease, high blood pressure, by experiments on dogs, peculiar people, like the anti-vaccinationists and the antivivisectionists, say nay, nay, with all their voices, all their votes and all their wealth And yet, the doctor must carry on.

So we see that medicine, specifically the science of medicine, is a hungry, omnivorous, but, I hope, humble and grateful bantling. He leans heavily on all science, but specifically on biology, chemistry and physics Like the ameba and the sponge, medicine absorbs nutrients from the boundless sea of science and is doing its utmost to organize this growing mass of facts and skills to the understanding and the service of man.

If this brief survey of the rôle of the fundamental sciences in medicine is even approximately correct, several consequences seem to follow, consequences so pregnant in their portents as to make us all pause and ponder:

(1) *Medical education and medical research are becoming increasingly complex, time-consuming and costly.* But we can see no other way. There are no short cuts.

(2) *The conscientious practice of modern medicine is becoming so complicated and costly as to almost exceed the intellectual capacity of the ablest men.* Again, I see no cure for this Who shall bear the necessarily increased cost of modern medical service, the individual or society? I do not know the wisest way

(3) *No university will be able to maintain a medical school of distinction, without great men also in biology, chemistry and physics.* And pygmies in the humanities and the social sciences aid medicine not at all

I would put first things first in this field, and that is *able men* In the past third of a century I have listened to endless discussions on the minutiae of the medical curriculum. I have seen drives for bigger and better teaching and research hospitals, bigger and better teaching and research laboratories. I have listened to plans for "coordination of research" from people who do not have their milk teeth, not to speak of their wisdom teeth, of research Talk comes easy. But real medical research and conscientious medical practice take everything that the ablest of us can deliver It is not a union schedule of forty hours a week, but a sweating proposition of eighteen hours a day. And some universities, some university medical schools are still in the "stone age," aided and abetted by both public and private funds Look at the piles of brick and mortar, steel and stone towering towards the sky on almost every state and city university and college campus in our country the past ten years, largely through federal funds. In the mean-

time, how many new farthings have been invested in men in these institutions, in first-rate men? Look at the record, and weep! To my knowledge, big buildings and small men have never made great institutions But big men have frequently added mightily to our understanding of life in health and in disease, in primitive surroundings and with meager equipment For years and years, it was my great privilege to walk and talk with Michelson, Millikan, and Compton, Neff and Stieglitz, Chamberlin, Moulton, and Moore, Whitman and Lillie, Loeb and Coulter, Billings and Hektoen, David Starr Jordan and William Rainey Harper Only two of these challenging spirits were medical men If I have in any way contributed to medical education and medical research, this is due largely to the example and the challenge of such men

Fifty years ago the echoes of the red man's war-whoops had scarcely died on our western prairies, and the bleached buffalo chips still littered the plains The sod hut of the first settler and the song of the ax in our primeval pine forest to the north were harbingers of a new era in man's conquest of nature It takes labor and sweat, patience and wisdom to conjure forth the fruits of the soil and the iron from the bowels of the earth

But it takes infinitely more labor, more wisdom, more patience and more cash to establish and maintain that social and intellectual soil and climate necessary for the development of the finest qualities of men. Science, medicine, to-day and to-morrow, are a part, but only a part, of that soil and climate The farmer, the man in the mart, the teacher, the statesman can also significantly accelerate these processes, but only if the seed sprouts in the understanding of the common man When every farmer leaves his acres a little better than he found them, when every worker leaves the imprint of human honesty and human dignity on every task performed, however humble, when every lawmaker helps to render human relations a little more equitable; when every judge leaves his court a tradition of a little more justice, when every doctor, every teacher, every investigator work more for love and less for hire, when every statesman leaves the path of compromise, conciliation and approximate justice a little more accessible and secure, we shall have something greater than fat cattle, marble palaces, tall buildings, radios defiling the pure ether with black lies and mighty airships spewing pain and death on women and children Even then, we shall not have perpetual health, not even perpetual youth But we shall be well on the road to earn the designation *wise men.* We shall still struggle for life and light, but shall have left behind the follies, the fears and the fights of the jungle.

THE PRACTICE OF MEDICINE IN TUDOR ENGLAND

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I

FAR too much has been written and published about the brave and novel world of sixteenth century England A recent illegally anonymous article (from the historian's point of view) revealed to the reader that, upon the subject of medical history at least, the writer's imagination paid large and immediate dividends We historians, most of us rejoicing heirs of logical precision, are left inert and vaguely sad when confronted with something that professes to be "history," and is not. We may grow acid and austere when pseudo-historians, who know a few of the tricks of our laboratory, release their arrogant and unsubtle assertions upon the world We may attempt desperately to keep our wills effective and our nerves in order and seem content with a staunch denunciation of lesser breeds without the law. We may seek security in flight. Finally, we may attempt to explore more fully the subject that has presumably already been discussed (in our circles we describe it felicitously as "a re-examination of pertinent data") and arrive at a new thesis that is more or less defensible.

II

The names of distinguished men of medicine who lived in the age of the Tudors seem to slip easily from our tongues We have noted them in a multitude of texts and monographs Thomas Vicary, William Clowes, Thomas Gale, John Caius, John Banister, Thomas Cogan, Andrew Boorde, Christopher Salmon, William Bullein, these are a fitting part of the century of More and Colet and Erasmus. We may perhaps include Buttes and Bentley and Ayliffe, who frown proudly from Holbein's famous picture of the physicians of Henry VIII. Students of the history of medical science will find it difficult, however, to extend the roll of honor without impressing Baker or Gerard or the contemptible Whetstone from the streets. We are surprised, for we had concluded the great Renaissance physicians were legion. Now they appear but a few digits in the crowd. There is, of course, some truth in the point of view accepted by fond lovers of the glorious and golden age of the Tudors. There were physicians of no mean stature. There were advances in medical science and pubilc health.

On the other hand, there is much more truth in another sort of view The skilled and learned physicians in Tudor England were few The competent surgeons were few. Most of these depended for their skill and knowledge upon their studies in Padua, Leyden, Basel, Montpellier and Heidelberg The universities did not provide a sufficient number of practitioners for the public. The larger part of the practice of medicine was in the hands of men who possessed few pretensions to medical knowledge and, frequently, even fewer to respectability.

The influence of the Renaissance in the field of medicine in England was not significant. The ferment caused upon the Continent by Vesalius's "De Humani Corporis Fabrica" raised but feeble echoes, even in Oxford, Cambridge and London. Little was known of Paracelsus but his name. The authority of Galen may have been weakened within a restricted circle but to most he still remained the "prince of physic" and the

"lantern of surgeons." Considerable and varied evidence indicates that England took no active part in the medical Renaissance of the Continent until the appearance of Harvey's "de Motu Cordis" in 1628 In the field of plague medicine, as Professor Charles F. Mullett has argued elsewhere in the pages of the SCIENTIFIC MONTHLY (April, 1937), the advance was more marked. English medical achievement here lies only in the field of preventive medicine. Once the pestilence had struck, in the words of Thomas Nashe's lament, "physic himself must fade."

III

Before the days of Mayerne and Harvey medical students in the universities usually had clerical status. In 1539, largely because of "the bustling of the university up and down" in matters of religion, John Caius left Cambridge to seek peace at Padua. There the great Vesalius taught him anatomy, a subject frowned upon by the ecclesiastics at home Upon his return to England, Caius lectured before Henry VIII, became physician to Edward VI, Mary and Elizabeth. Meanwhile he wrote the "Liber de Ephemera Britannica" (1555) and a curious tract "On English Dogs" (1576) Much of what Caius says in the latter essay seems a little obscure and it is unnecessary to do more than suggest the general content.

> Little dogs are good to assuage the sickness of the stomach, being often times thereunto applied as a plaster preservative or borne in the bosom of the diseased and weak person which effect is performed by their moderate heat Moreover, the disease and sickness changeth his place and entereth—though it be not precisely marked—into the dog, which is an untruth, experience can testify.

At the University of Cambridge, where he was to give his name to a college, Caius lectured and dissected until the "idolatrous objects" were burned in the college quadrangle by students who, mindful of the St. Bartholomew's Massacre, in 1573 denounced the Roman Catholic doctor of physic.

The career of Caius may stand as illustrative of the biography of several of his contemporaries. There were, of course, many who had no opportunity to study with the masters on the Continent or, like the erratic Andrew Boorde, physician to Henry VIII and author of the "Breviary of Health" (*c* 1542) and the "Introduction to Knowledge" (1553), to travel "through most parts of Europe." To these the army offered the only possible avenue to clinical experience. Indeed, the fact is that the army was more important in Tudor medical history than the English universities. The handful of university graduates, bred in the literature of Galen, walled round with pride, were not prepared to voyage adventurously in seas that the medieval masters had not charted A failure to draw a distinction between a Cambridge training and an army experience must always result in a serious misunderstanding of the origins of the few contributions to the enrichment and the stimulation of medical thought in sixteenth century England.

The obvious, or it might almost be said the inevitable, representative of the army men is William Clowes, the Elder. Now Clowes served with Leicester in the Low Countries where "bad surgeons slew more than the enemy" In 1575 he entered St. Bartholomew's Hospital There he produced some of the best surgical writings of the age, almost unique in that they were more than the usual compilations from authorities, the acceptable "proved practice for all young surgeons." Clowes never sought patients or battled with those who deplored his opposition to orthodox surgical methods—"scornful scanners, their commendations I disdain." Those who know the story of his son's encounter with the impostor Leverett will suspect that the youth inherited something of the uncertain temperament of the choleric father.

With the forces of Henry VIII in 1544 was Clowes's contemporary, Thomas Gale. From the army Gale returned to London to write his "Treatise on Gunshot" (1548) and a small volume on surgery (1563). Meanwhile his famous styptic powder conquered England until Clowes's powder proved more effective, when the public sought the better nostrum.

It is unnecessary here to multiply instances of others, like John Woodhall, who came from the army with unusual technical experience Of one thing we may be certain Few Englishmen published tracts that could compare with those of Clowes and Gale, for the latter included their own experiences and their own conclusions.

Far more typical of Tudor medical literature is the work of John Banister or George Baker Banister delighted in compilations One of these embraced nine volumes and bore the title "The History of Man Sucked from the Sap of the Most Approved Anatomists" (1578) Baker wrote treatises on pharmacy and distilled medicine and translated pages of Guido, Virgo, Galen and Gessner Frequently he lapsed into Latin—"I woulde not have every ignorant asse to be made a chirurgion by my book, for they would do more harm with it than good " Even the great Vicary, physician to Henry VIII and Elizabeth, in his "Treatise of the Anatomy of a Man's Body" (1548, 1577, etc) made no reference to European medical science or to his own experience The reason for the omissions was an excellent one. Vicary had copied, without acknowledgment, a fourteenth century manuscript No changes seemed necessary and none were made His intimate acquaintance with and his affection for Guido de Cauliaco is indicated by a sentence from Vicary's will: "Also I give and bequeath unto the hawle of my company one book called Guido " (This was surely Guido's "Cyrurgia" of 1363 and not his treatise on anatomy.)

IV

In another context it has been suggested that the medical schools in England were still lamentably weak The great bequest of Linacre had almost no immediate effect upon medical education in Oxford In the period 1571–1600 Oxford gave only forty-seven medical degrees Theological contention filled the minds of men in universities still devoted to the traditions of the past. There is also evidence in plenty that medical degrees were often given carelessly. The College of Physicians once complained to Cardinal Pole of the admission of ignorant and unlettered men Most scandalous were the cases of Ludford, a Franciscan friar who became an apothecary in London, and of Laughton, a coppersmith who could not decline *corpus*

The academic laws of Oxford seemed rigid enough and doubtless there were periods when regulations were strictly enforced and the lethargic monotony of the university broken The rules of Oxford declared that the student of medicine and surgery must study six years. He must dispute twice, respond once and see two anatomies before securing his bachelor's degree He must perform two anatomies and effect at least three cures before being admitted to practice. Yet even had there been no evasions of the college law, Oxford was not England The best, if not the most famous, of the medical students sought the Continent or the army So distressing did the situation appear at the middle of the century that a special commission was sent to Oxford by Edward VI with power to assign one college solely to the study of medicine

In an England where competent and licensed practitioners were few there were many opportunities for unlicensed folk with significant phials to take advantage of the fear and ignorance of the sick.

"Itaque hercule evenit ut cuicumque medicum se professo statim credatur." The sixteenth century, like the twentieth, was confronted with the problem of protecting the gullible. As early as 1511 Linacre probably wrote with his own hand the preamble to an Act of Parliament designed to crumple the quack.

> Forasmuche as the science and connyng of Physyke and Surgerie, to the perfecte knowledge whereof are requisite bothe grete lernyng and ripe experience, ys daily within this Royalme exercised by a grete multitude of ignoraunt persones, of whom the grete parte have no manner of insight in the same, nor in any other kynde of lernyng . . common Artificers, as Smythes, Wevers, and Women, boldely and customably take upon them grete curis, and thyngis of grete difficultie, in the whiche they partely use socery and whichcrafte, partely applie such medycyns unto the disease as be verey noyous, and nothing metely therefore, to the high displeasure of God, grete infamye to the faculties, and the grevous hurte, damage and distruccion, of many of the Kinges liege people, most specially of them that cannot descerne the unconnyng from the connyng . . . let noo person within the citie of London, nor within VII miles of the same, take upon him to exercise and occupie as a Phisicion or Surgion except he be first examined, approved and admitted by the Byshoppe of London, or by the Dean of Paul's for the tyme beyng, calling to hym or them iiii Doctours of Phisyk and for Surgerie, other expert persones in that facultie. . . . And over thys, let noo person . . . take upon hym to exercise and occupie as a Physician or Surgeon in any Diocese within this Royalme but if he be first examined and approved by the Bisshop of the same Diocese. . . ."

With the assistance of the Church the medical fraternity of London attempted to enforce strict observance of the licensing laws Their success was not complete, but at least it was far superior to the haphazard and sporadic attempts at control in the country. Rural England became the playground for every type of quack and charlatan.

In 1578, due to concerted action by Linacre and his followers, the charter of the Royal College of Physicians was granted "The example of well-governed cities in Italy and many other nations" together with the English desire to advance and ensure her medical standards contributed to the foundation of this new Royal College, a college that was on the one side an academy, on the other a gild. It is particularly significant that the six leaders of the infant college possessed foreign medical degrees. In 1522 the power of the college was extended by an Act of Parliament supplementing the Act of 1511. The preamble suggests the continued attempt to crush the amateurs. "It was expedient and necessary to provide that no person be suffered to exercise and practise physic but only those persons that be profound, sad and discreet, groundedly learned and deeply studied in physic." Therefore a monopoly was bestowed upon the college. No person except a graduate of Oxford or Cambridge was to be allowed to practise physic in London unless examined and approved by the college.

Between the physician and the surgeon of Tudor England there was fixed a wide gulf Physic was a profession; surgery a trade In 1540 the two companies of the Barbers and Surgeons were united No barber might practise surgery (except toothdrawing) and no surgeon might shave. The Barber-Surgeons Company was always a poor company, in part because of its rank in the social scale. It is true that the King encouraged the study of anatomy by permitting the Company to dissect a number of bodies from Tyburn's gallows. Yet they were almost equalled in number by the Skinners Company, the Haberdashers and the Fishmongers Seldom did they succeed in boasting a membership of two hundred. In city processions and gatherings they held seventeenth place. Once they slipped back to twenty-eighth place and once they were ousted altogether But they had their own ordinances "of the mystery of Barber-Surgeons," as did the famous Barber-Surgeons of York whose rules survive in the Egerton Manuscripts in the British Museum. To enforce their

statutes the London Barber-Surgeons had their own courts. In 1557, according to the Guildhall records, they judged twenty offenders; in 1572 forty-one; in 1599 forty-six. The attempts of the Royal College of Physicians to lift the level of their profession was aided by the Barber-Surgeons, from policy and ambition astute and jealous guardians of the art of surgery.

One of the immediate results of established privilege was the reduction of the number of licensed practitioners Consequent also upon the fact that the universities produced so few physicians demands arose for remedy "Since surgeons are so few . . . and London folk fall ill" the Surgeons of London were excepted from service on the Watch, Juries, Constableships through an agreement with the Corporation of London In 1531 Parliament had enacted that alien surgeons were not handicraft men and therefore not subject to the statutes against alien artificers for exercising handicrafts A decade later the Barber-Surgeons Company did not enjoy the prospect of alien encroachment and competition With reluctance bordering on panic they accepted a solution to a knotty problem, contenting themselves with bombast and oblique references to the vicious results of the foreign intrusion In spite of the fact that "opportunity was taken by the evil-minded to worry alien surgeons" a number came from the Continent to England. After careful scrutiny on the part of the English many of the foreign surgeons were permitted to practise There were also, of course, physicians from the Continent. In 1541 John Malyard of Normandy demonstrated his excellence before the Royal College of Physicians and was granted leave to work with English patients. In 1542 John Lytster of France was finally allowed to practise when his "cures" became famous, although he had been previously "interrupted therein by the physicians of thys citye because he was not admitted so to do by the Bysshoppe of London, according to the lawe." So, too, Peter Van Duran of Amsterdam finally found the doors hesitantly opened where native physicians and surgeons were too few to serve the city. Jealousy, monopoly and instinctive distrust of foreigners were alike compelled to retreat before the critical necessity of the age.

Late in the reign of Henry VIII it was decided that a part of the difficulty might be overcome if the physicians were permitted to practise surgery. The Royal College, indeed, had been rapidly extending its powers All the city apothecaries, for instance, had their wares of drugs and medical supplies examined by four representatives of the college Physicians were finally permitted to practise surgery, but surgeons were forbidden by an Act of Parliament of 1543 to practise physic. "No common surgeons may administer medicine outward . . . for although the most parte of the said craft of surgeons have small coonning, yet they woold take great soomes of money and doo little therefore; and by reason thereof they doo oftentymes impaire and hurte theyre patients, rather than do them goode"

The difficulties that confronted the Royal College of Physicians and the Barber-Surgeons Company in London were not easily surmounted Regulations alone could not produce complete submission. Evasions of the law were numerous enough; invasions of the city by those who masqueraded as physicians and surgeons made the licensed and competent medical men grow desperate. When George Whetsone wrote his "Touchstone for the Time" to describe the conditions of the Elizabethan London he knew so well he drew down upon himself the wrath of his fellows in the professional circles, in large measure because it was felt his description of slum conditions was unseemly and because he adopted a style reminiscent of John Bales's explosive and indelicate sentences. To them

Whetstone was a "quaint" writer who wrote too much for "the ignorant multitude of people." The learned physicians and the less learned surgeons were troubled even in the citadel of their power

Without the centers of population the regulations were quite ineffective. Andrew Boorde, in his "Breviary" (*c* 1542) raised a loud lament. "O lorde, what a great detriment is this to a noble science, that ignorant persones wyl enterpryse to medle with the ministrations of phisicke " Thomas Vicary echoes Boorde in describing the "ignorant practitioners who, not knowing the anatomie, commonly ensure death, and the separation of soule and body "

It would not be difficult to multiply illustrations of the profound sorrow of honest practitioners when they beheld the charlatanry of the villains who deluded the sick and the sound Such a situation, happily long foreign to the modern age, moved the heart of the splenetic pessimist, Philip Stubbs With dismay he contemplated a ruined England and anatomized the abuses of a once great profession

The good, learned and discreet physicians are necessary and may do much good, so the unlearned and the naughty (as the world is too full of them) may and do much heart daily, as experience teacheth . . now-a-days every man, tag, and rag, of what insufficiency soever, is suffered to exercise the mystery of physic, and surgery, and to minister both the one and the other, to the diseased, and infirmed persons, but to their woe, you may be sure

This bringeth the laudable sciences of physic and surgery into hatred, obloquy and contempt, makyth it of no estimation in the world and utterly discrediteth it among men . Great pity it is therefore, that there is such liberty in permitting every one that lust to profane and abuse these venerable sciences of physic and surgery as they do . . we see a sort of vagrants, who run straggling (I will not say roguing) over the countries . . . they rake in great sums of money, which when they have got, they leave their cures in the dust, I warrant you, and betake them to their heels as their best refuge . Physic is good and yet I would not have every ignorant dolt that knoweth not the use nor benefit thereof, to practise the same.

Even the licensed practitioners came in for the wrath of Stubbs. He denounced those who "rustle it out in the silkes and velvets" for their high charges He described them as unctuous gentlemen who piously observed, the patient dead, his money gone—"Death is a cruel tiger, who spareth none " He accused them of being in league with the apothecaries who sold "chalk for cheese" and "druggy baggage " Then, too, "as long as money runneth, they will apply gentle and easy potions, medicines and salves but, *deficiente pecunia,* money wanting, they apply bitter potions, nipping medicines, gnawing corrosives, and pinching plasters to grieve their patient withal, thereby to strain out what liquor of life (that is, what money or goods) they are able to give "

It has frequently been observed that in this age of versatility recipes for medicines and strange cures were multiplied The Galenic theory of the four humours extended deep into the popular mind and was not easily shaken The belief in supernatural causes and diabolical machinations gave ground but slowly Henry VIII himself dabbled in medicine, and his plasters and potions were probably as good as the rest "The King's Majesties own plastre" was made of "the pythe of marshmallowes" and linseed and good white wine "A certain black plastre devised by the King's highness" was a compound of plantain, violet and honeysuckle leaves mixed with the "fatte of capons" and perhaps was able to "take away inflammacions and cease payne and heale excoriacions." Henry VIII also concocted "decoccions" and "waters" and through the long records of his court march Dr Augustyne, Dr Buttes and Dr. Aylhffe with "a gallon of milke and a quarte of faire water" or "three sweet appuls" or "nightshade, mallowe and violette."

The problems of plague medicine and public health have received more attention from the historian than any other

aspect of Tudor medical history. Most of the literature is well known. All students of the subject are aware that curious preventive measures for the plague ranged from Thomas Cogan's orange a day ("Haven of Health") to Simon Kellaway's "cataplasms" ("A Defensative Against the Plague") William Bullein, in "A Dialogue Against the Fever Pestilence" (1564), a book less frequently studied than it deserves to be, admits that there are times when "physike cannot prevaile" and yet finds comfort in the fact that there are many potions and powders and perfumes and pills that may be used with some effect against the plague. Here, in an anagram, Dr. Tocrub represents the famous Dr. Burcot, "though a stranger, yet in England for phisicke famous" (Chettle, "Kind-Hart's Dreame," 1593) and Tocrub speaks with ease and knowledge of Galen, Hippocrates and Avicen, declaring to all the importance of the physician. "Honour the physician with the honour that is due unto him because of necessitie, for the Lord hath created him; for he shall receive gifts of the king, yea and of all men " Dr Tocrub has also certain goodly rules against the plague "Let all men, women and children avoide out of the evill ayre into a good soyle and then, accordyng to their age, strength of nature, and complexion, let every one of them with some good medicine draw from the body superfluous moisture, and diminish humours, hotte and dry, and use the regiment of diet to drying, sharped with vinegar or tart things, and lesse meates, not so much wyne as they have used in custom, nor angers, nor perturbations of the mind, especially the passion called fear."

The less familiar "Loseley Manuscripts" contain several letters from physician Simon Trippe to patient George More. On September 18, 1581, Trippe wrote: "On Fryday and Saterday the signal will be in the heart, on Sunday, Monday and Tuesday in the stomake, during which tyme it will be no good dealing with yoor ordinary physike untill Wensday come sevennight at the nearest, and from that tyme forwards for 15 or 16 days passing good " In the "Loseley Manuscripts" are also carefully listed "medical receipts and the astrological precautions, some of which are assigned to Master Galien (Galen) leche " A single instance will be sufficiently illustrative "*For hym that may not slepe:* Take and wryte yese words into leves of lether · Ismael! Ismael! adjuro te per Angelum Michaelum, ut saporetur homo iste; and lay this under his bed, so yt he wot not yereof, and use it allway lytell and lytell, as he shall have need yereto."

The most famous of the Tudor medical men, graduates of Continental universities or of the army, were usually found at the court, the hospitals or the universities The suppression of the monasteries, gilds and chantries (and that event has never been studied sufficiently by students of social history) increased the need for public care of the afflicted poor, for in earlier days the monks had frequently maintained hospitals as part of their foundation (See especially Conrad Gill, "Studies in Midland History," Oxford, 1930) With the dissolution of the religious houses and with the increase in enclosures the cripples, lepers, discharged soldiers, rogues and beggars trekked desperately into London and other cities Those with loathsome or contagious diseases were rapidly confined in the lazar-houses at Knightsbridge and Hammersmith and there the warning clang of the leper's bell became daily more familiar

In 1544 Henry VIII founded St. Bartholomew's Hospital for 100 patients In spite of a scandal in 1552 in which charges were brought against the Hospital by citizens "having al their zeale in

their tongue only" St. Barts succeeded in accomplishing much good work. When a patient was discharged from the hospital he was given a passport and required to report within a specified number of days at "the place of his nativity" to the mayor or constable. Thus an attempt was made to force the departure of a number of public charges from the city of London.

In 1553 letters patent of Edward VI gave Bridewell to London. Bridewell was in fact a prison-hospital, for the city was ordered to take up and commit to the House of Labour at Bridewell all "idle, lazy ruffians, haunters of stews, vagabonds and sturdy beggars, or other suspected persons whomsoever, and men and women whomsoever of ill name and fame." There at least some of the idle and masterless vagabonds were taken in an effort to abolish beggary in Edward's London.

Edward VI established three other royal hospitals At St. Thomas' Hospital were kept about two hundred aged and sick (in spite of countless efforts of the inmates to escape) At Bethlehem, due in large part to the work of modest Richard Grafton, conditions were superior to those in other havens. At famous Christ's Hospital the largest endowment of the King found opportunity "for the entertainment of poor distressed and diseased persons till they got well . . for the maintenance . . . till the age of seven years of all such children whose mothers die in the house" The last and smallest of the London hospitals was Savoy Hospital, suppressed by Edward VI and restored by Mary. For the great city there were no more, and in spite of the work they attempted to do their success, in proportion to the need, was small.

VI

Enough evidence has here been presented to compel the conclusion that the great advances in art and literature and exploration and science in Tudor England were not equalled by the development of medicine. Men were redrawing the world, but the clinical study of disease was just beginning. When there was no English pharmacopeia and the apothecaries still had no charter to sell or purchase drugs, when the men of medicine guarded jealously their medieval secrets, then, certainly, there was no dawn and no renaissance to make its sure and steady way. Even after Mayerne and Gilbert the great Evelyn could speak in praise of the healing qualities of "rain water of the autumnal equinox, exceedingly rectified, very volatile," and John Symcotts, as Professor F G Marcham has remarked, could write learnedly of the properties of the mysterious "lohock in the pot." Chaucer, long before, had turned to pen an ironic description of the physic of his own day. It would not, perhaps, have been unfitting in the glorious days of Henry and Elizabeth.

And certainly where nature will not wirck,
Farewell, phisike, go bere the corse to chirch.

RELIGION IN A SCIENTIFIC ERA

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I WRITE on the subject of this article in a very humble frame of mind. I am not a professional student of religion nor in any sense am I qualified to discuss either its technical or its deeper philosophical aspects Perhaps some of the things which I shall say will not be generally approved. But I am venturing to write on this subject because I believe that there are some basic aspects of the much-discussed relationship between science and religion to which the thoughts of both scientists and others can profitably be directed.

For one thing, it is interesting to note the widely contrasting views of able thinkers on this subject At one extreme is the scientifically minded British philosopher, Bertrand Russell, who said, "My own view on religion is that of Lucretius I regard it as a disease born of fear and as a source of untold misery to the human race" We must admit some basis for this statement: much of the development of religious doctrines has centered around a desire to escape fears and ills and to gain some advantage (Parenthetically I should say that these are not unworthy aims, though not on as high a plane as some of the more unselfish aspirations that have motivated religion.) Also we must admit that centuries of warfare, persecution and exploitation in the name of religion have brought "untold misery to the human race"

Quite a different note is struck by another great contemporary thinker, the scientist Robert A Millikan. He says, "There is no incompatibility between science and the essential purpose of religion, which is to develop the consciences, the ideals and the aspirations of mankind; but individual religions, or branches of religion, often contain more than this essential, and much that is objectionable. Personally I believe that essential and not dogmatic religion is one of the world's supremest needs."

A basic difference in attitude toward religious matters was illustrated by a conversation I had about fifteen years ago with a fundamentalist professor of one of the Christian theological schools. Realizing that we were far apart in our thinking, I tried to see if there was anything on which we could agree; so I asked him two questions which I thought would give us a common starting point But when he replied I was startled to realize the width of the gulf between this religious leader and practically the entire group of my own acquaintances

My first question was this: how old is the earth? Attempts have been made, by those who interpret the Old Testament as an infallible historical record of events, to date the origin of the earth on the basis of the seven days of creation plus the genealogical record from Adam and Eve through to the times of ordinary historic record. These estimates come out to be less than 10,000 years.

On the other hand, scientists have numerous methods of estimating geological age. For example, measurements of the rate of erosion of rocks by flowing water indicate that at least hundreds of thousands of years must have been required for the Colorado River to carve out the Grand Canyon Measurement of the rate of depositing sediment at the mouth of the Nile or the Mississippi similarly points to hundreds of thousands of years as required to produce their great deltas The same answer

comes from estimates of the time required for the rivers, carrying the salts that are continually dissolved from the ground by fallen rain, to have carried into the oceans the amount of salt that is in them to-day. But most accurate of all is the measurement of the age of rocks by their content of radioactive materials and products. These materials are like tiny clocks, embedded in the rocks and ticking away the centuries entirely unaffected by heat, cold, pressure or chemical combination Here scientists believe they have an accurate measure of geologic age, and can date rocks in terms of hundreds of millions of years

In view of this evidence, I said to my theological acquaintance, How can you hold to the literal historical interpretation of the Scriptures as giving a geological age less than 10,000 years? He replied, "You scientists make the assumption, which you can not prove, that the scientific laws which you find true to-day were also true a thousand or more years ago I prefer to make the assumption that the Holy Scriptures are absolutely accurate" Seeing that I could not reach common ground here, I tried the second question. "Which is more important, the virgin birth of Jesus Christ or his teachings, by word and by example, regarding the attitude that men should take toward their fellow men and toward God?" He replied, "The virgin birth is by far the more important because, if this be not accepted, we have no basis of authority on which to accept his teachings" I tried to argue that the teachings stood on the authority of their own merit, as proven by experience, and that it would seem strange to me to place the ideals which Christ exemplified and to which he devoted his life in a position subordinate to the manner of his birth But again we could reach no common ground

In describing this incident I know that I have taken an extreme case But this present-day illustration is typical of a long evolution in religious thinking. A few thousand years ago nearly every phenomenon of nature was attributed to the act or command of some god or goddess. To-day, instead of praying to gods of wind, rain and sun, we study the reports of the weather bureau, and our meteorologists know the causes and basic laws of the motions of air masses and the formation of clouds and rain. Formerly crops were thought to depend on the degree of benevolence of the goddess of the harvest; to-day we know definitely their dependence on the quality of seed, nature of soil, distribution of sunshine and rain and control of insect pests.

A few centuries ago the idea that the earth is not the center of the universe was held to be a death-blow at the Scriptures, for was it not declared that the sun riseth in the east and setteth in the west, and that the stars run through their orbits? The acceptance of our present astronomical concepts was one of the greatest wrenches in the early Christian Church, for it was the first of a long series of defeats of the then existent ideas of "infallibility and limitless authority" in which the organized church had clothed herself

A second wrench came with the acceptance of the idea that the earth is spherical. Navigators even before the time of Columbus knew this fact well, though their ideas about the size of the earth were inaccurate But the church fought this idea, pinning its faith in the biblical phrase, "the four corners of the earth." At one stage in the controversy a queer compromise appeared; maps of the known world were given a shape like a bulging square, or a circle distorted with four cusps, in order to keep the notion of four corners and yet give grudging recognition to the knowledge of navigators and astronomers

In our own day many of the churches have been fighting a similarly losing

battle against the theory of evolution. Some twenty-five years ago, when my wife was in Y W C A work, she visited many colleges where the teaching of evolution was forbidden and the name even was mentioned only in whispers. Groups of girls used to request her to meet them off campus and enlighten them as to the meaning of this forbidden subject And yet for several generations scientists have seen an increasingly clear record of evolution in the age-long development of plants, animals and to some extent of man, as disclosed in the study of skeletons and fossils But what is more, we are now producing new species of plants and animals in our laboratories, using x-rays or radium or certain chemicals to accelerate processes which have certainly been going on naturally ever since life has existed on this planet It is even reasonable to expect that this controlled process of evolution may soon be in commercial operation A number of industrial and agricultural laboratories have been experimenting with it

All the preceding remarks bear on the much-discussed question "Is there a conflict between science and religion?" I believe it may be helpful to point out that the answer to this question depends upon the claims of the religion If a religion essays to make pronouncements regarding the materials, laws and forces of nature, whether laws of physics or astronomy in the inanimate world or laws of biology or heredity in the animate world, then the religion will certainly come sooner or later into conflict with advancing knowledge of science, and will certainly be the loser in the conflict Those religious persons of fundamentalist leanings may resent this situation, and lay the blame on the upstart scientists of the last hundred years who have rushed in where angels feared to tread If any feel thus, I would refer them to a *real* fundamentalist of fifteen centuries ago, St. Augustine, who wrote

There is some question as to the earth or the sky, or the other elements of this world—respecting which one who is not a Christian has knowledge derived from most certain knowledge or observation. and it is very disgraceful and mischievous, and of all things to be carefully avoided, that a Christian speaking of such matters as being according to the Christian scriptures should be heard by an unbeliever talking such nonsense that the unbeliever, perceiving him to be as wide from the mark as east and west, can hardly restrain himself from laughing.

Permit just one more illustration which aptly bears on St Augustine's theme While Benjamin Franklin was making his experiments on the nature of lightning, and his invention of the lightning rod was finding wide and successful use in New England, some of the great clergymen of Boston became greatly exercised over this sinful interference with God's power to strike his wayward children with fear and punishment through thunder and lightning And when an earthquake shook this region, it was proclaimed from the pulpits as God's warning against such interference with his powers This attitude by the clergy certainly reduced the respect held both for them and their religion

On the other hand, science has not encroached upon the basic functions of religion, which have to do with man's aspirations, ideals and motives which guide his emotional adjustment to the world and to his fellow man Even here science may also play a rôle, through correction of glandular disorders or psychological maladjustments which so often warp man's outlook on life and lead to antisocial or irrational behavior. But, granting all this, I believe that there is a fundamental religious instinct in man that craves expression, and that there is a great realm of spiritual values and satisfactions in which religion and not science has its rôle.

With these observations as a background, let me proceed to a few more positive considerations

(1) The sources of such conflicts as

have occurred between religion and science are to be found in matters which are really no part of religion They are either the remanents of old superstitions or are accretions which have become attached to religion like barnacles to a ship. Many of these accretions have come through the efforts of religious men to work out a philosophy of life in all its aspects, and have become ingrained in church doctrines But, like barnacles, they have impeded rather than aided religious progress I believe that science has rendered a great service to essential religion in unshackling it from these incumbrances and thus assisting it in developing more clearly its fundamental objectives

(2) The impact of science on religion has emphasized its dynamic, as opposed to static, character. An extreme example of static attitude is implicit belief in the literal accuracy and permanent perfection of the scriptures of the Jews or the Bible of the Christians The dynamic attitude is to view those documents as the story of man's continual progress in evolving a religious attitude toward his environment and all that this environment implies. With this viewpoint, grotesque contradictions disappear We see the evolution of his concept of God from an anthropomorphic conception of numerous deities of capricious behavior and often conflicting purposes, through the notion of a single God who walked and bargained with men, who chastised them and repented, to the conception of a great spiritual force operating through natural laws which are understandable and dependable and at least partly discoverable through science We see the picture of a continual development in ideas of right and wrong from the early notions of obedience to sets of rules to concepts of social justice and human welfare We see notions of salvation and eternal life becoming less concentrated on selfish considerations and more concerned with service to others and the permanent contribution of our individual lives to the future welfare of mankind. This dynamic concept of religion as a continually evolving and developing spiritual force is inspiring and acceptable in a scientific world. In my judgment the static concept of religion is sterile, discouraging and unacceptable.

(3) I believe there is justification, and even need, for a variety of religious denominations, which emphasize different aspects of that complex thing that we call the spiritual life There are two reasons for this belief. The first is that there are many different types of persons: some are emotional, others are severely analytical, some are philosophical, others are active; some like to take initiative and responsibility, others like to be led and directed So it is natural that there should be churches or other religious organizations where each person can find the type of fellowship and opportunity for expression and activity which will give him the best spiritual satisfaction and development

A second advantage in having some diversity in religious organizations is that a certain amount of diversity makes for virility and progress This appears to be true in all aspects of life It is the diversity of plant life that maintains such life despite diseases and pests which attack and perhaps destroy one or another type Existence of different types of social organization gives the experience on which sound improvements can be made. In general the tendency for all to herd together makes for safety, conservatism and stagnation, whereas the tendency for expression of individuality leads to risk and progress, though at the expense of some confusion. I suspect that this holds true in religion as in other aspects of life So, on both counts, I do not agree with some who wish that all religions and churches

might combine under one common faith and doctrine

(4) A corollary to this last point of view is the need for tolerance and mutual respect between different religious groups. The basis for such tolerance is found in the essential similarity of what I would call the basic objectives and attitudes of all religions. They may differ in emphasis on various points, they may even hold contradictory views on some matters, but all religions worthy of the name possess common ideals of goodness, of unselfishness and service, of reverence for a power which transcends our human strength and understanding The work of the National Conference of Catholics, Protestants and Jews is a fine example of enlightened effort to stand together for such essentials and to be tolerant and respectful of each other's differences

(5) In recognizing that religion deals with spiritual interests and values, while science is supreme in the field of observable facts and logical relationships, it is proper to remember that, even in the realm of nature, science has its limitations which are not always appreciated Science never discovered the ultimate origin or purpose of anything. It can find out *how* the universe works, not what *caused* it or what *determined* the way it works, or its *purpose* or its ultimate *destiny*. If any religion wishes to include a speculation regarding these matters, science can not gainsay her, for these are outside the realm of science. But, in my judgment, they are also outside the proper realm of religion and, being probably incapable of any proof by observation or deduction, are left only to imaginative speculation.

In conclusion, if I were to try to describe the position of religion in a scientific world, I should summarize the situation about as follows:

The entire history of the contact of religion and science shows that the facts of the world and of life which are capable of observation and test constitute a realm in which science is supreme. Science has not supplanted and can not supplant or destroy religion in its proper sense It can, however, give a setting to which our thoughts on religious matters must conform Science has continually forced men to take an ever-wider and grander concept of religion by breaking down artificial barriers of ignorance and superstition Its whole tendency has been to emphasize the fundamentally spiritual character of religion as representing the highest ideals and aspirations of mankind as opposed to theological rules, doctrines, theories, etc. Science has therefore had tremendous influence in shifting the emphasis of religion from the physical to the spiritual world and we must not shut our eyes to the possibility of still further powerful influence of this sort.

Science has thus contributed to the making of religion into a developing, dynamic spiritual force I believe that the principal influence of science upon religion has been along the following lines First, to break down "authority" and substitute reason based upon facts of observation Second, to eliminate superstition and chicanery from religion. Third, to doom any religion of the static type and emphasize the necessity of a continual development of religious thought to keep pace with and interpret the increasing knowledge regarding all matters which pertain to man's activities and environment.

BOOKS ON SCIENCE FOR LAYMEN

DUALISM IN THE MODERN PHYSICS[1]

MORE than two centuries ago a serious argument arose between the famous Englishman, Isaac Newton, and the somewhat less famous Dutchman, Christian Huyghens The question was about the physical nature of light, and, whereas Newton was advocating the corpuscular theory, considering light as a flow of a great number of very small particles, Huyghens was of the opinion that we deal here with wave-propagation in a certain all-penetrating medium called the world-ether The subsequent development of physics led to the triumph of the Huyghens's wave-theory of light, and only in the twentieth century have certain aspects of Newton's point of view come back to the spotlight of physical science It was indicated by Albert Einstein that the so-called photoeffect-phenomena can be understood only on the basis of the hypothesis that the energy of light is carried through the space in the form of individual energy-packets or light-quanta Soon after that, the beautiful experiments of Arthur H Compton have also shown that in the interaction of light with material particles (electrons) it behaves as if it were really formed by individual corpuscles in the old Newton's fashion

At the same time as the old corpuscular point of view on the nature of light was slowly regaining its position in physics, serious doubts had arisen in the questions concerning the motion of the ordinary material particles The quantum phenomena of the new physics found their interpretation in the ingenious and revolutionary ideas of Louis de Broglie, who was first to see that these phenomena definitely indicate the presence of certain wave-properties also in the case of motion of ordinary material particles. The experiments of Davisson and Germer gave an excellent proof to these, at first sight, very unusual ideas, showing that a beam of electrons produces the same kind of diffraction-phenomena as an ordinary beam of light-rays.

As a consequence of this new development, modern physics arrived at a certain dualistic point of view, both in the theory of light and in the theory of material particles, and a profound analysis of the situation brought forth a complete change of our most fundamental concepts concerning the nature of motion Instead of the absolute determinacy characterizing the theories of the classical physics, we are faced now with the new "uncertainty principle" of motion, established and developed by the works of Werner Heisenberg and Niels Bohr

The book of Louis de Broglie, who was responsible for the introduction of the wave-ideas into the mechanics of material particles, represents an excellent analysis of the development of the "dualistic-crisis" in the modern physics and of its resolution by the present system of physical theory In the various sections of the book, the author of the wave-theory of matter approaches from different points of view the difficulties arising in the study of the relations between matter and light, and indicates the ways by which these difficulties can be removed It is a great pity, however, that the book is not written "from the beginning to the end," but represents rather a collection of different separate lectures and addresses cemented together by a number of specially written chapters This causes a considerable lack of homogeneity of presentation, and whereas some sections are written in a very popular way others require a knowledge of very advanced mathe-

[1] *Matter and Light (The New Physics)* By Louis de Broglie $3 50 300 pp W. W Norton and Company, Inc, New York

matical theories. The difference in the time of delivery of various lectures and addresses included in the book causes also such regrettable effects as we find, for example, at the end of the chapter IV2 After discussing for several pages the "extreme obscurity" of the principles of wave-mechanics (the chapter represents an address delivered more than ten years ago), the author makes the footnote indicating that at present the difficulties are removed and that "the interpretation of the New Mechanics in terms given by Heisenberg and Bohr (to be discussed later) has been practically universally accepted "

There is hardly any doubt that much more satisfactory results could be obtained if the author would find the time to write a consistent presentation of the present state of the problem, instead of cementing the book together from different originally unconnected pieces However, even as it is, the book is very interesting reading, both from the historical and the present points of view.

The technical edition of the book is also very good, except of the picture of the "solar eclipse" (?) appearing for no apparent reason on the jacket

G. Gamow

YEARS WITH MORPHEUS[1]

This is the first scholarly and complete book on sleep since the appearance of Piéron's in 1913. It contains references to a bibliography of 1,400 titles of more or less learned works—most of them more learned—which have appeared since Piéron or, in some cases, were overlooked by Piéron Dr Kleitman's citations are selective, but made with scientific discernment

Sleep is a subject of wide interest to laymen, but this is not a book for them. It is an important book, however, for workers in the fields of physiology, biology and psychology and is a "must get" for every educational library

Starting with apparent differences between sleeping and wakefulness, it is found that complete muscular relaxation during sleep is a myth, that blood and circulatory changes are artifacts due to the horizontal posture, that the shunting of blood from the brain in sleep should be a dead ghost

Then turning to what happens during sleep, lack of uniformity from person to person becomes apparent, and the important fact emerges that "transition" conditions from wakefulness to sleep indicate a continuous rather than a discrete process

In the following several chapters rhythmic features common both to sleep and wakefulness are considered, showing the apparently basic part of diurnal variations in the cycle of day-to-day life

Next the experimental possibilities and results of altering these cycles are presented, including such natural interruptions of the cycles as by narcolepsy, epilepsy, sleeping sickness, drugs and hibernation

In the sections on the hygiene of sleep a confused state of affairs is discovered, perhaps because exceptions outweigh the general rule

The book concludes with an evolutionary theory of sleep and wakefulness which appears to Dr Kleitman to reconcile the greatest number of established facts Being awake is interpreted as having something superimposed on the basic features of sleep, it is individually acquired, not superimposed by cosmic powers, and is chiefly a matter of habit formation and conditioning

Throughout the book the influence of the fine critical and experimental hand of Professor Anton J. Carlson, with whom Dr Kleitman works, is apparent, from plain-spoken criticism to Spartan philosophy and emphasis on the machinery of man and animals. Psychoanalysts

[1] *Sleep and Wakefulness.* By Nathaniel Kleitman Illustrated with charts $5 00. xii + 638 pp University of Chicago Press, Chicago, Illinois.

will feel that more attention should have been given to their approach, particularly in the sections on insomnia, dreaming and sleep-walking; we may be confident that their injured feelings will not disturb the author and his co-workers.

DONALD A. LAIRD

REFORMATION OF CRIMINALS[1]

JUDGED by the standards of world history, prisons are a relatively new institution in dealing with criminals; nevertheless, they have been in use for at least a number of generations. a little over two hundred years, to be more explicit. In all this time they have been operated largely on the theory (if any) that if they could be made unattractive and repulsive enough they would, by some strange magic, "deter" the prisoner from further offending or perhaps even "reform" him Along with many other legal institutions, they have exerted themselves precious little to try to understand the human material with which they deal, and to ascertain by such understanding whether they might increase their efficiency as machines of social defense.

In relatively few localities, and only for a score of years or a little more, has there been an introduction into the scheme of prison management of psychiatry, that specialty of medicine which deals with abnormal conduct Even this modest intrusion has met with opposition, and only this year New York State, which had developed an outstanding system of prison psychiatry, abolished the work upon the alleged ground of "economy"—an act which may well in the long run reflect itself in increasing recidivism and resulting cost.

The Federal Government, fortunately, has consistently developed in its penitentiaries and reformatories an integration of psychiatry with its program of classification, education and rehabilitation, and it is upon the basis of their experience in this system that the authors have prepared the present volume—in many ways a pioneer in its field.

The authors, employing the classification adopted by the American Prison Association, divide prisoners into six groups, namely: normal, feeble-minded, psychoneurotic, psychopathic, neuropathic and psychotic. There are chapters on each, with a discussion of the definition, the types of reaction and the relationship of the abnormality to crime. The authors point out that feeblemindedness and psychosis (mental disorder) are not the all-controlling factors in crime that various writers in the past have fancied them to be, but that rather the groups they refer to as psychopathic and neuropathic furnish a substantial number of recruits. On the other hand, they emphasize the existence of influences in the ordinary prison which may conduce to mental disorder, and offer suggestions for improvement in the mental hygiene of the prison There are chapters on the homosexual prisoner, the recidivist, on discipline in prison and the value of imprisonment The "Appendix of Landmarks and Dates in the Development of Prisons" is extremely helpful for purposes of orientation One quotation will serve to indicate the authors' philosophy:

> The reason that imprisonment cannot bring about true reformation lies in the fact that this form of punishment involves a rigid regimentation and outwardly imposed discipline which in the last analysis is nothing but a poorly camouflaged manifestation of force, and reformation can never be forced upon one. It must come from within (p. 263).

The book is written in an eminently practical style, with little recourse to too-technical language. It is, all in all, a volume which should be read by every citizen who has an intelligent interest in the hitherto much-neglected problem of

[1] *Problems in Prison Psychiatry.* By J. G Wilson, M D, and M J. Pescor, M.D. $3.00. 276 pp Caxton Printers, Ltd, Caldwell, Idaho

dealing with our convicted offenders. May there soon be more such citizens!

WINFRED OVERHOLSER

"QUEER BIRDS"[1]

AT a time when scientists are too often represented as being magicians, a development of the proposition that they are more or less ordinary human beings is salutary This volume, which apparently is included in the British "The Library of Science and Culture" series of books, has for its purpose much more than simply maintaining this thesis: it examines the nature of science itself

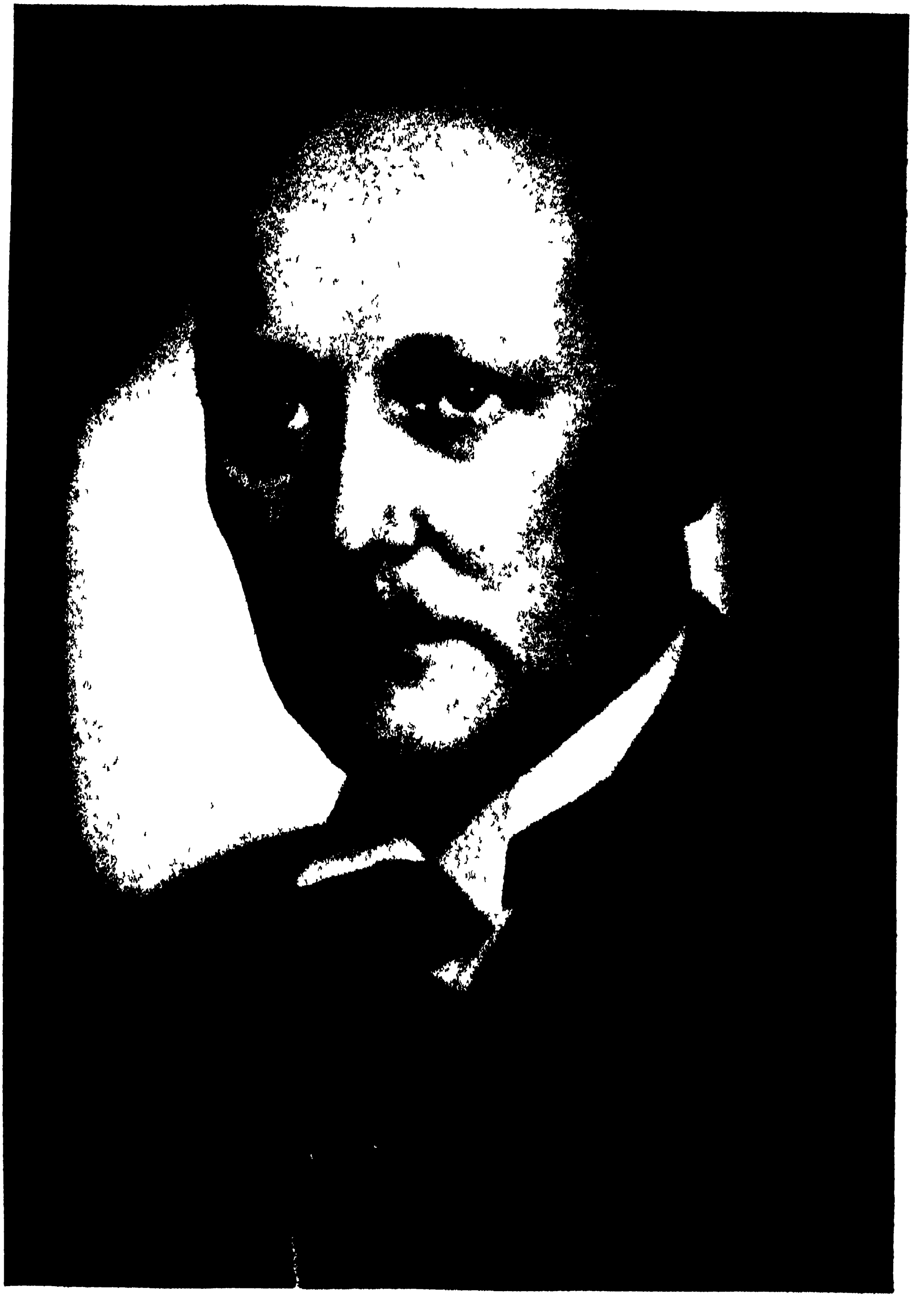
The first chapter is directed to the title of the book and reaches the conclusion " that the virtues and vices that the scientist shares with less impressive mortals enter infallibly into the findings of science and affect its reliability," a statement which no scientist would question Then follows a short chapter with the startling title, "The Unmasking of Logic," which consists only of comments on various recently proposed extensions and modifications of the Aristotelian logic, particularly the rejection of the law of the excluded middle The next chapter on the characteristics of scientists has more than a slight resemblance to cartoons of them. According to the author, distinguished scientists are solitary geniuses ("queer birds"), physically ailing and subject to mental unbalance Celebrated scientists are named who are said (probably with some justice) to have had one or more of these characteristics. But it would be easy to select an equal number of distinguished scientists who have the opposite characteristics A comparative study, with respect to these qualities, of random selections of enough scientists (distinguished), actors, clergymen, newspaper men, physicians, farmers and day laborers to justify statistical conclusions would be interesting and perhaps would dispel the widely held theory that scientists are not really human. If by some chance the American Nobel Laureates in science were selected, the scientists would be represented by men who in respect to urbanity, good health and vigor (both physical and mental), cheerfulness, hopefulness and happiness it would be difficult to surpass At any rate, it would be worth while to determine whether there is any relationship of introversion and extroversion with "genius "

The fourth chapter has for its thesis the proposition that science is an expression of the social organization There can be no doubt that science and the social order affect each other profoundly and reciprocally, a fact that inspired the series of conferences on "Science and Society" that have been held at several meetings of the American Association for the Advancement of Science during the past two years, and which are being continued. The difficulties of getting scientific work recognized are greatly exaggerated by the author, and his criticisms of persons in authority who suppress work of their inferiors imply a prevalence of this evil that by no means exists

The last two chapters in the book on the psychological and philosophical nature of science are admirable and thought-provoking These chapters not only constitute more than half the book, but from the point of view of penetrating analyses, they *are* the book Carefully read, they will give the lay reader a new understanding of the essence of science, and no less will they be of interest and value to most scientists The subjects they discuss are worthy of the careful attention of scientists, psychologists and philosophers

F. R M.

[1] *Scientists are Human.* By David Lindsay Watson, with a Foreword by John Dewey. $2.25. xx + 249 pages Watts and Company, London.



THE PROGRESS OF SCIENCE

AWARD OF THE NOBEL PRIZE IN PHYSIOLOGY AND MEDICINE TO DR. GERHARD DOMAGK

THE 1939 Nobel prize for physiology and medicine has been awarded to Dr Gerhard Domagk, of the I G Farbenindustrie, Wuppertal-Elberfeld, Germany He is compelled to reject it, but it was eminently fitting that the prize should have been given for the development of Prontosil Rarely, indeed, has the development of a therapeutic remedy been followed as promptly by so wide-spread a practical application, with such enormous benefits to so many people

The story of the development of this compound, while still obscure in certain details, is nevertheless fascinating In 1908 Gelmo prepared para aminobenzene sulfonamide (sulfanilamide) A year later Professor H Horlein (at present a director of the I G) in conjunction with Dressel and Kothe, prepared sulfonamide-containing azo compounds in a search for dyes possessing a marked degree of fastness to washing and fulling In 1919 Heidelberger and Jacobs synthesized an azo compound by linking dihydrocuprein with para aminobenzene sulfonamide This compound was stated to be (along with certain other quinine derivatives) bactericidal in the test-tube, but no further investigation of this property was made

In 1920, the I G Farbenindustrie postulated the preparation of 2 4-diamino azobenzene-4'-sulfonamide, later called Prontosil, in the English patent No 149,428, but apparently nothing further was done about it until sometime between 1930 and 1932 It must be remembered that the I G has always had a lively interest in chemotherapy, and especially so since the discovery of arsphenamine by Ehrlich Hence, it is not at all surprising that following the first world war, a series of investigations (probably initiated by Professor Horlein) were carried out in the field of bacterial chemotherapy

As far as can be ascertained from published reports (which unfortunately are very scant) studies were made in the I G laboratories upon the chemotherapeutic effects of certain gold derivatives, hydroquinine preparations, acridine and other compounds None of these, however, proved to be very effective Then attention was turned to the azo compounds, especially those similar to the chrysoidins, because it had been claimed that pyridium and selenium possessed chemotherapeutic effects in urinary tract infections

The synthesis of the azo-compounds was entrusted to Drs Fritz Mietzsch and Joseph Klarer, and although certain azo dyes prepared by these chemists showed definite bactericidal effects *in vitro,* they were without chemotherapeutic activity *in vivo* It is at this point that Gerhard Domagk enters the scene Domagk was born in 1895 at Lagow in Brandenburg He had just entered the University of Kiel when the first world war broke out, and in October, 1914, he volunteered for the army, in which he served four years. At first he was in a grenadier regiment, but, after being wounded in 1915, was transferred to the medical corps for the remainder of the war

After the armistice he returned to his studies in Kiel and received his degree in medicine in 1921 In 1924 he was appointed lecturer in general pathology and pathological anatomy at the University of Greifswald. He remained there for a little over a year and then left to become a member of the Pathological Institute at Munster At this period in his career, Domagk was interested in the effects of x-ray upon the kidney—especially in relation to the production of experimental nephritis

In 1927, he left Munster to join the staff of the experimental pathological and bacteriological laboratory of the I G Farbenindustrie at Wuppertal-Elberfeld, and at the present time he is director of this laboratory It is only natural to find that after joining the laboratory at Wuppertal, Domagk interested himself in products fabricated by the I G Between 1927 and 1935 he seemed mainly concerned (at least in so far as his publications indicate) with a new vitamin A concentrate and the treatment of piroplasma infection in dogs with trypflavin One of Domagk's duties was to test the chemotherapeutic effects of the various compounds synthesized by Mietzsch and Klarer, and we now know that at least one effective compound was elaborated before Prontosil The original (and only) protocol of the value of Prontosil in the control of experimental streptococcal infections in mice is dated December 20, 1932 On Christmas day, 1932, Mietzsch and Klarer applied for patents covering not only Prontosil but also several other sulfonamide-containing azo dyes These patents were granted on the 13th of December, 1934

However, long before these patents were granted and before Domagk's original paper was published, reports began to appear in the German medical literature regarding the therapeutic effects of Prontosil The first was read by Foerster on May 17, 1933, before the Dusseldorf Dermatological Society, and it seems from this report that the drug must have been distributed for clinical trial as early as March, 1933

The February 15th, 1935, issue of the *Deutsche Medizinische Wochenschrift* contained Domagk's original paper on the chemotherapeutic activity of Prontosil in the control of experimental streptococcal infections in mice In this report he discussed the physical properties of the dye, gave brief data upon its toxicity for animals and described its extraordinary therapeutic effects in mice which had been inoculated with streptococci He pointed out that the drug was ineffective *in vitro* and that it acted as a true chemotherapeutic agent only in the living animal In many respects this is the best of the seven communications of Domagk upon the subject of bacterial chemotherapy. In his later papers he frequently seems preoccupied with proving the inferiority of sulfanilamide to the I G derivatives of this drug

This brings us to one of the historical puzzles of bacterial chemotherapy—namely, were the therapeutic effects of sulfanilamide known to the laboratory in Wuppertal-Elberfeld before they were first described by the Trefouels in France? The only information on this is the statement by Professor Horlein that sulfanilamide *had* to be brought out in Germany by the I G in 1936 because English and French investigators had shown it to be an effective chemotherapeutic remedy

This, then, is the story of the development of Prontosil It represents an example of the success which may be obtained when intelligent directing is coupled with unflagging chemical and biological investigations It is a pity that the I G Farbenindustrie could not accept the award which it so justly deserves.

In recognition of his scientific achievements, Dr Domagk received, however, in 1937, the Emil Fischer Medal, highest honor bestowed by the German Chemical Society, and, in 1939, the Cameron Prize of the University of Edinburgh, Scotland

Moreover, Dr Domagk has delivered lectures on recent developments in chemotherapy before learned societies in various countries of continental Europe and in England He had accepted an invitation to present a paper at the International Congress for Microbiology, which was held in New York last September, but the outbreak of the European war prevented his sailing.

PERRIN H. LONG
THE JOHNS HOPKINS MEDICAL SCHOOL

AMERICAN ASSOCIATION IN ACTION

TWICE a year the American Association for the Advancement of Science holds a meeting, its annual Christmas meeting at the close of December and its summer meeting usually in June In addition, the Pacific Division and the Southwestern Division of the Association each holds one meeting a year. Therefore, four times a year the Association is in action.

The word "action" implies something alive, at least dynamic It is no misuse of the word to apply it to the Association during its meetings, for in respect to the number of persons attending them and to the number of addresses delivered and papers presented, these conventions of scientists are notable if not unequaled The voice of science at the meetings of the Association is not a timid cry in the dark or a despairing wail from the wilderness, it rings with confidence in its methods for obtaining an understanding of the inanimate and the biological worlds, and it expresses in clear tones the hope that these methods may be successfully extended and modified to meet the complex problems of the inter-relations of men At a time when statesmen stand baffled by the present ills of society and tremble for the future of civilization, scientists, with a background of the long history of life on the earth and of the great progress of man, unafraid and with eager enthusiasm press forward into every accessible unknown region

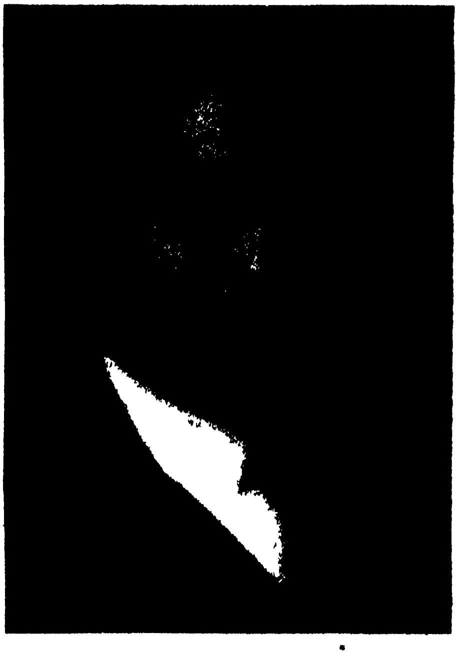
If the universe were a chaos there could be no science, for the fundamental basis of science is that natural phenomena recur under similar conditions A machine will not function unless its parts are constructed and integrated according to some deliberate plan Similarly, a great scientific organization will not measure up to its responsibilities unless it has clear purposes and adopts appropriate methods for achieving them One of the functions of the American Association for the Advancement of Science

AIRPLANE VIEW OF THE CAMPUS OF THE OHIO STATE UNIVERSITY

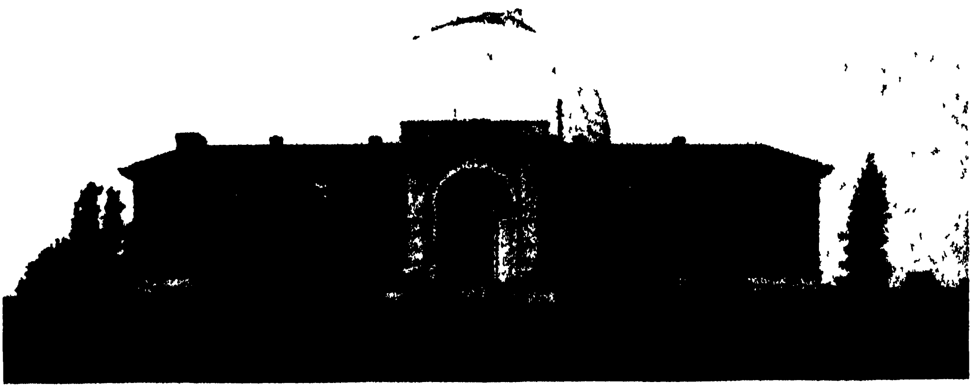
DR MARSTON MORSE
PROFESSOR OF MATHEMATICS, INSTITUTE OF ADVANCED STUDY, PRINCETON UNIVERSITY, CHAIRMAN FOR MATHEMATICS

DR ERNEST O LAWRENCE
DIRECTOR OF THE RADIATION LABORATORY, UNIVERSITY OF CALIFORNIA, CHAIRMAN OF THE SECTION ON PHYSICS NOBEL PRIZE WINNER, 1939

DR HENRY GILMAN
PROFESSOR OF ORGANIC CHEMISTRY, IOWA STATE COLLEGE, CHAIRMAN FOR CHEMISTRY.



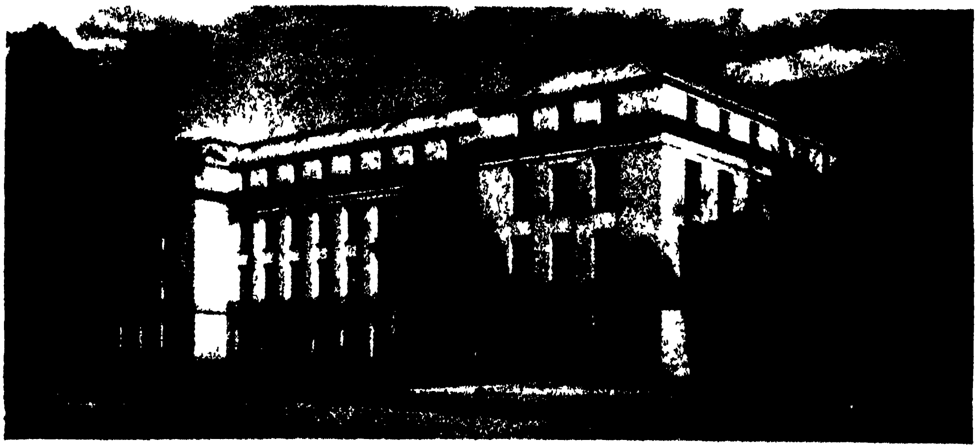
DR EVERETT I YOWELL
DIRECTOR OF THE CINCINNATI OBSERVATORY, CHAIRMAN FOR ASTRONOMY



THE PERKINS OBSERVATORY
OF THE OHIO WESLEYAN UNIVERSITY AND THE OHIO STATE UNIVERSITY

is to integrate the numerous subdivisions of science that have arisen during the past few decades The extent to which this function is exercised by the Association is indicated by the fact that 169 different scientific societies and organizations are now affiliated with it These affiliated societies and organizations have a total membership, including duplicates, of nearly a million persons

At the meetings of the Association there are two kinds of programs, those of such a general character as to be of interest to all intelligent persons and those that consist of technical addresses and papers for specialists It is through programs of the former kind that the Association becomes most obviously an integrating agency At no meeting of the Association have its general programs been more interesting and important than those of the meeting which has just been held at Columbus, Ohio The address of the retiring president of the Association, Dr Wesley Clair Mitchell, a distinguished economist and professor in Columbia University, was on "The Public Relations of Science" At a time when science is credited by some persons with all progress and blamed by others for all ills, no subject could be more appropriate The light radiated by science certainly has dazzled a world unaccustomed to such brilliancy. Perhaps



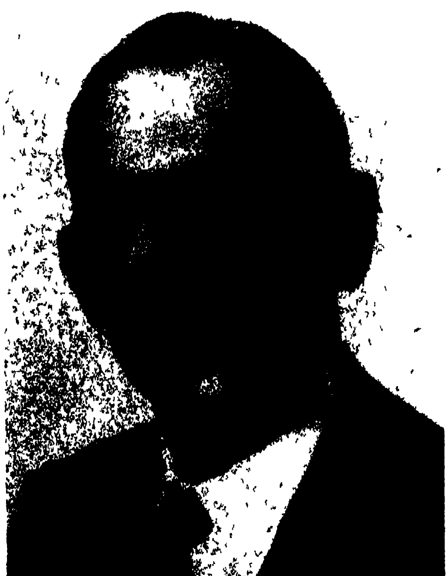
COMMERCE AND ADMINISTRATION BUILDING
THE BOTANICAL SOCIETY OF AMERICA WILL MEET IN THIS BUILDING

DR KIRK BRYAN

SENIOR GEOLOGIST, UNITED STATES GEOLOGICAL SURVEY, CHAIRMAN FOR GEOLOGY AND GEOGRAPHY

it may become "a pillar of fire" to guide mankind out of the darkness in which it now stumbles

A little more than a year ago the Association arranged with the British Association for the Advancement of Science for an exchange, on alternate years, of lectures before their respective meetings by distinguished scientists of the two countries. The British chose Dr Isaiah Bowman, president of The Johns Hopkins University, to deliver the first exchange lecture by an American scientist before the British Association The meeting at which Dr Bowman was to speak was scheduled for early September in Dundee, Scotland With one of the largest registrations in its history and one of its best programs to be presented, German armed forces proceeded by air and land against the Polish people, the British and French Governments declared that a state of war existed between their countries and Germany, and the meeting was completely destroyed Hearing the news while he was en route to Dundee, Dr



DR WESLEY R. COE

PROFESSOR OF BIOLOGY, YALE UNIVERSITY; CHAIRMAN FOR THE ZOOLOGICAL SCIENCES

DR NEIL E STEVENS

PROFESSOR OF BOTANY, UNIVERSITY OF ILLINOIS, CHAIRMAN OF THE SECTION FOR THE BIOLOGICAL SCIENCES

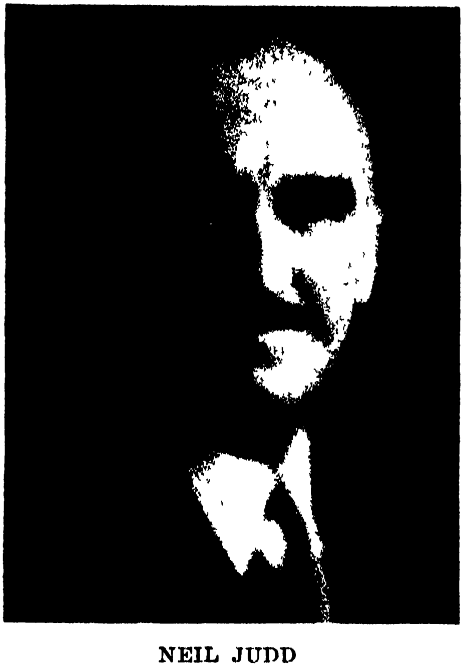
Bowman stepped off one train, crossed the platform, boarded another train for his port of sailing, "and left the world in darkness and to me (them) " Not permanently in darkness, we have faith to hope, for within ten years after Waterloo did not "Ardennes wave above them (the unreturning brave) her green leaves" again? And will not again the better natures of men prevail?

Although it was expected that a lecture by a British scientist would not be given under the arrangement between the two associations until next summer, the American Association was very fortunate in securing Dr Julian S Huxley, of London, to deliver the return address at the Columbus meeting His subject, "Science, War and Reconstruction," illustrates the sense of responsibility to society that scientists feel and the statesmanship with which they grapple with the acute problems now before the world

The title of Dr Huxley's address is arresting, for it implies not only a survey of the present but plans for the future

DR CLARK L HULL

PROFESSOR OF PSYCHOLOGY AT YALE UNIVERSITY, CHAIRMAN OF THE SECTION ON PSYCHOLOGY



NEIL JUDD

CURATOR, DIVISION OF ARCHEOLOGY, UNITED STATES NATIONAL MUSEUM; CHAIRMAN OF THE SECTION ON ANTHROPOLOGY

DR WARREN S THOMPSON

DIRECTOR, SCRIPPS FOUNDATION FOR RESEARCH IN POPULATION PROBLEMS, CHAIRMAN FOR SOCIAL AND ECONOMIC SCIENCES

DR JEROME C HUNSAKER
HEAD OF DEPARTMENT OF MECHANICAL ENGINEERING, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CHAIRMAN FOR ENGINEERING

DR L C KARPINSKI
PROFESSOR OF MATHEMATICS, UNIVERSITY OF MICHIGAN, CHAIRMAN FOR THE HISTORICAL AND PHILOLOGICAL SCIENCES

Why should not a scientist appraise the forces that are now molding society? They certainly have been produced by science It is science that has suddenly made all men neighbors, and also competitors for such raw materials as foods, fuels, metals and cellulose. It is science that has provided them with new methods of preserving health by international quarantines, and also placed in their hands new means of destruction It is science that has enabled one man to talk

DR CARL J WIGGERS
PROFESSOR OF PHYSIOLOGY, WESTERN RESERVE UNIVERSITY SCHOOL OF MEDICINE; CHAIRMAN FOR THE MEDICAL SCIENCES

to millions and to concentrate their energies on a single objective, whether it be peace or war

When we remember how generally opinions respecting any important period of the world's history have changed with time, we realize how difficult it is to evaluate the forces that are producing current events Perhaps scientists, with a background of the history of life on the earth in their minds, and accustomed to the objectivity of science, will be able satisfactorily to appraise the nature of

the forces that are now causing strife in the world Such an analysis is what Dr. Huxley gives in his address He does not stop, however, with comments on the present problems of society. Like all thoughtful persons, he anxiously looks toward the future, and he outlines programs for making it better

The address of Dr Huxley indicates a great change of point of view since the days of the World War Then the objectives of both sides were winning the war and punishment for enemies Now it is recognized that, when the dark clouds of war have passed, the problem before all men will be to set up, in conference, a political organization of Europe that will preserve peace because it is based on sound fundamental principles As Dr Huxley states "But do not let us delude ourselves into thinking that it will be easy Wishful thinking issuing in impractical schemes is one of man's unique biological attributes"

In its technical programs the Associa-

DR M R TRABUE
DEAN OF THE SCHOOL OF EDUCATION, PENNSYLVANIA STATE COLLEGE, CHAIRMAN OF THE SECTION ON EDUCATION

DR HENRY SCHMITZ
PROFESSOR AND CHIEF OF DIVISION OF FORESTRY, UNIVERSITY OF MINNESOTA, CHAIRMAN OF THE SECTION ON AGRICULTURE

tion unites different fields of science to the advantage of all of them To appreciate these possibilities one has only to think of combined programs in the fields of chemistry and medicine, of education and psychology, of geology and mathematics, of genetics and botany and zoology To prepare distinguished programs that range across the usual boundaries separating the sciences requires both wide knowledge and imagination. Evidently no one person or small group of persons could cover all science For this reason the work of the Association is organized under fifteen sections in cooperation with the related affiliated societies Each section has a chairman, elected for one year, who is a vice-president of the Association Upon the retirement of these vice-presidents they deliver addresses that are often profound and brilliant surveys of broad fields of science These are the distinguished scientists whose portraits appear on the pages of this issue of the MONTHLY

F R MOULTON
PERMANENT SECRETARY OF A A A S

ANNUAL RESEARCH EXHIBITION OF THE CARNEGIE INSTITUTION OF WASHINGTON

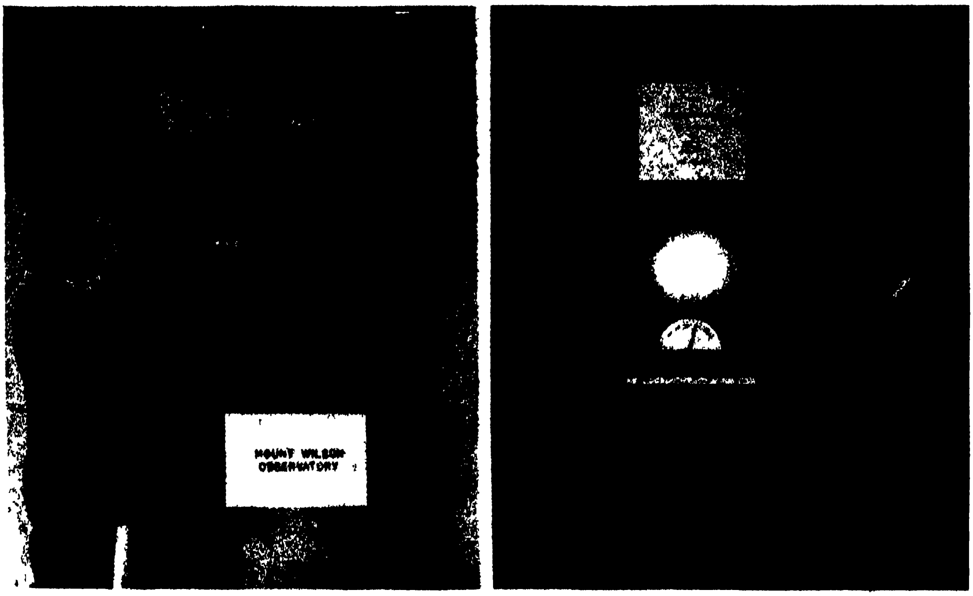
HIGHLIGHTS of some of the most recent scientific researches of the Carnegie Institution of Washington were on public exhibit at its Administration Building, 16th and P Streets, N W, on December 16, 17 and 18 The exhibits portrayed important discoveries in the fields of animal and plant biology and of the historical and physical sciences Each exhibit was explained by experts prominently identified with the researches, and short lectures relating to the exhibits were open to the public

A most unusual exhibit was the one on cosmic rays which, although originating outside the earth and passing through the walls and roof of the building, were actually detected and counted within the exhibit hall Many photographs were shown to illustrate how the masses, great speeds and electric charges of cosmic rays are deduced

In a demonstration of atom splitting, the uranium atom was broken down to produce other elements such as iodine in forms having the radioactive properties of radium. The important use of the "artificially radioactive" substances thus produced in tracing the course of chemical reactions was explained and illustrated

Moving models demonstrating the behavior of the magnetic compass and its changes since 1600 were shown in an exhibit dealing with the earth's magnetism The modification of Columbus' voyage, had he followed present compass directions, illustrated the value of this knowledge Models showed internal magnets reproducing the earth's magnetism and its changes Relations of magnetic changes to other natural phenomena were also touched upon

The exhibit of the Geophysical Laboratory was devoted to its work on the gases in rocks and their relations to volcanic activity and geology The specimens and charts shown helped to visualize the ways



PROFESSOR A H JOY WITH EXHIBIT OF THE MT. WILSON OBSERVATORY
Left DEMONSTRATING THE MODEL OF A METHOD FOR SHOWING THE ROTATION OF OUR GALAXY OF STARS *Right* DEMONSTRATING A MODEL SHOWING THE VARIATIONS IN DIAMETER AND TEMPERATURE OF A CEPHEID VARIABLE STAR

SURFACE VIEW OF THE GLANDULAR LINING OF THE UTERUS.
SHOWING EVERYWHERE THE OPENINGS OF THE MOUTHS OF THE UTERINE GLANDS. SOME OF THE GLANDS ARE NOT OPEN. IN THE CENTER IS A PROMINENCE DUE TO THE PRESENCE OF THE OVUM WHICH HAS JUST SUNK BENEATH THE SURFACE. THE MATERNAL EPITHELIUM HAS NOT ENTIRELY HEALED OVER THE TOP OF THE OVUM. THE ACTUAL SIZE OF THE PROMINENCE IS ABOUT 1.0 MM. THE GROWTH OF THE OVUM FROM THIS TIME ON ACQUIRES NEW IMPETUS BECAUSE OF ITS PREDATORY POWERS ON THE MATERNAL TISSUES.

in which gases move about in the earth's crust and the effects of different amounts and intensities of volatiles.

A very striking exhibit of the Division of Animal Biology was the showing of two perfect human embryos approximately eleven days old—the earliest stage of human development which has yet come under direct observation. With the aid of lantern slides and moving pictures, these embryos and the developmental processes which they reveal were described and compared with those in other mammals. Another exhibit of this same division interpreted the results of the transplantation of leukemia in mice of the same and of different genetic constitutions. Protection experimentally induced is effective against leukemic cells which have passed through a long series of transfers from animal to animal, but not against the natural or spontaneous occurrence of leukemia. A third exhibit of this division was of interest to dieticians and others interested in problems of diet because it showed the rates at which various vegetables, fruits, nuts, sugars, etc., are burned in the human body and how quickly their energy contents are made available.

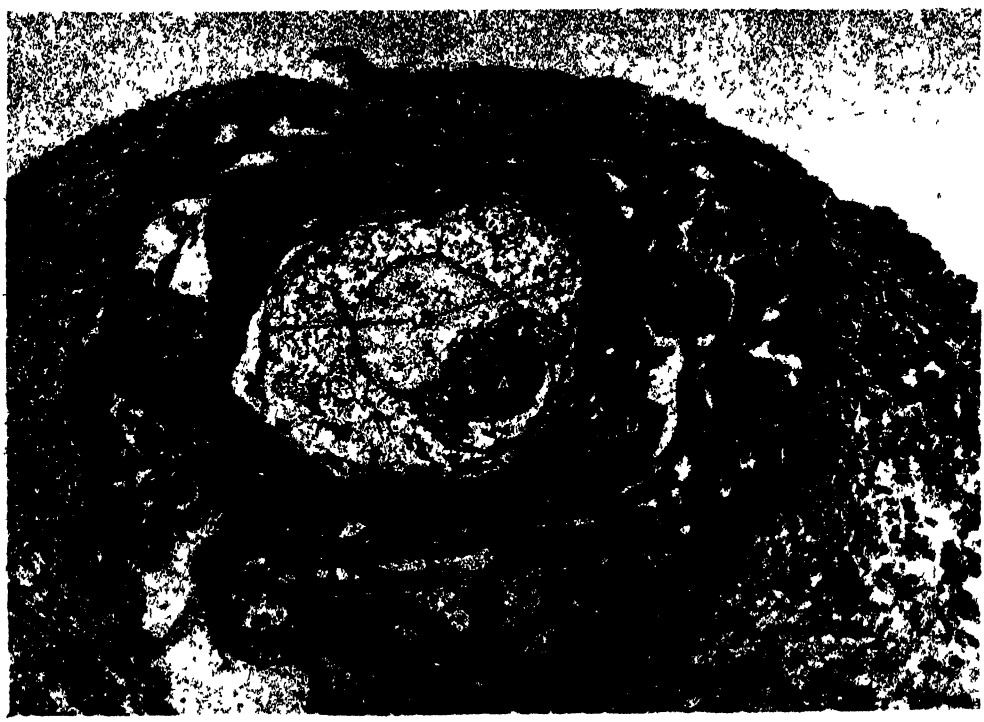
The exhibit of the Division of Plant Biology illustrated, through a number of substances derived from plants, the significance of molecular configuration in living things. The carbon compounds utilized for plant growth exist in two forms identical in chemical composition but differing in the arrangement of atoms

or groups of atoms within the molecules, the differences in arrangements being shown by models The two forms, which are unsymmetrical, differ from each other as the right hand differs from the left. If the plant is offered food to which it is not accustomed it will starve

The exhibits of the Mount Wilson Observatory showed the nature and distribution of the pulsating variable stars, illustrating the periodic changes by means of models. Such stars are extremely interesting astronomically, in part their characteristics may be used in the measurements of immense astronomical distances The exhibit also described and illustrated by diagrams and models the method for showing the rotation of our galaxy of stars Photographs of other rotating systems were shown Improvements in the technique of astronomical photography were also exhibited, especially the use of red light for photographing distant stars involved in scattered obscuring materials By the use of red light numbers of new stars have been discovered that can not be detected by ordinary photography.

The exhibit of the Historical Division showed the successive stages of the growth of an ancient Maya Temple-Palace by means of a series of restored drawings of a ruined temple group at the ancient Maya city of Uaxactun in northern Guatemala, which was excavated by Carnegie Institution As a result of alterations and additions during the course of several centuries it grew to one of the largest structures in the city

Stereoscopic projections of color pho-



A CLOSE-UP OF THE OVUM, ENLARGED 300 DIAMETERS

EARLIEST STAGE OF THE HUMAN EMBRYO EVER OBSERVED *A* EMBRYO PROPER, *B* · A PRIMITIVE COB-WEB LIKE TISSUE WHICH "CONDITIONS" THE FLUID IN WHICH THE EMBRYO PROPER IS DEVELOPING—AT THIS TIME ESSENTIALLY A TISSUE CULTURE *C* MATERNAL BLOOD CELLS BEING CONSUMED BY THE OVUM. *D* SHELL OF OVUM ERODING AND CONSUMING THE MATERNAL TISSUES. *E*. EMBRYO-MATERNAL JUNCTION. *F* MATERNAL TISSUE *G* MATERNAL EPITHELIUM HEALING OVER THE POINT OF ENTRANCE OF THE EGGS.

tographs from Yucatan, the surface of the moon and monkey and human embryos were shown at intervals during the exhibit This demonstration illustrated some of the possibilities of three-dimensional projection as applied to scientific purposes

T H D

NEW PLANS FOR RELATED ARTICLES IN THE SCIENTIFIC MONTHLY

READERS of THE SCIENTIFIC MONTHLY will recall that several articles have recently appeared in it on each of a number of subjects of importance and wide general interest For example, during the past year it has published "Religion in Science," by Sir Richard Gregory; "A Scientific Basis for Moral Action," by Professor Max Schoen, and "Does Science Afford a Basis for Ethics," by Dr Edwin G Conklin In about the same period the MONTHLY has also published "Science and Social Values," by Dr. E V Cowdry, "Which Way Science," by Dr Harlan True Stetson, and "Science and the World of Tomorrow," by Dr Robert A Millikan

Plans are now under way for carefully planned articles in various fields Subjects of importance and of exceptional interest to intelligent persons are selected and each of them is analyzed into a number of unitary subdivisions which together cover the whole field fairly completely Then a distinguished authority is invited to write on one of each of these subdivisions. The complete series of articles to be published on each subject will constitute a non-technical survey by experts As a rule only one article on any of these general subjects will appear in an issue of the MONTHLY, and not always will the various ones of a series appear in successive numbers

Since a concrete example is often more illuminating than an extended description, the plans for the several series of articles that are being developed will be illustrated by the program for those on "Problems of Advancing Age" This subject is among those chosen because the problems of advancing age are ones that every person who is not prematurely struck down by accident or disease must eventually face Even those who are riding the flood streams of life can rarely escape considering these problems, for everybody has relatives or acquaintances who are entering the shadows

The problems of advancing age are extraordinarily numerous and varied For example, the rapidly increasing fraction of the population subject to the ailments and diseases of senescence is shifting the center of interest of medical science This increase in the relative number of aged presents equally serious problems in connection with all plans for retirements and old-age pensions In fact, there are repercussions of it in our entire social, economic and political structure.

The following outline for a series of articles on "Problems of Advancing Age" was prepared by Edward J Stieglitz, M.D, who has already contributed to this particular series in his article on "High Blood Pressure," which appeared in the July, 1939, number of the MONTHLY

I General Introduction to the Subject (Dr E V Cowdry, this issue)
II The Biology of Aging
III High Blood Pressure
IV Mental Changes in Old Age
V The Old Heart
VI Nutrition and Digestion in Old Age
VII Cancer and Old Age
VIII Public Health Aspects of Old Age
IX Industrial Employment and Old Age
X. Age and Intellectual Work
XI Investment of Leisure in Old Age.
XII Old Age and the Family Organization.
XIII Philosophy of the Senescent (by some aged man).
XIV. Philosophy of the Senescent (by some aged woman)

Although each author will treat in his own way the subject he may write upon, Dr. Stieglitz has made an outline of the several topics, primarily to indicate their scope and their relationship to the whole series In order to illustrate the nature of these outlines, numbers II, VI and XIII and XIV will be briefly summarized

The Biology of Aging

A Senescence as a biologic process—its relationship to growth, metabolism, gonad activity, premature senescence, infection, immunity and tumors.

B Senescence in lower forms of life—experimental studies of low forms, the cell, tissue changes, relation between growth period and normal span of life, factors that advance or retard senescence

C Aging in systems of the body—the nervous system, respiratory system, circulatory system, digestive system, glands, skin, balance-control mechanisms

Naturally the treatment of some of the subtopics of this subject will be considered in other articles For example, the discussion of the heart will be more extensive in the article on "The Old Heart"

Nutrition and Digestion in Old Age

A. Food and metabolic requirements—nature of requirements and variations with age

B Obesity and longevity—statistics on relationship of obesity to longevity, biologic implications, amount and character of food, frequency of eating

C Changes in digestive abilities with age—in teeth, stomach, bowels, chemical factors.

D Sugar tolerance in old age—diabetes incidence, cause, degree, discovery, control, requirements of blood sugar in the aged

Philosophy of the Senescent

Occasionally a man or a woman attains great age in physical and mental health Such persons are models and inspirations Cicero in *De Senectute* most gracefully described their pleasures and satisfactions, but Cicero was not aged (he died at 63) when he wrote his delightful reflections Perhaps, as Dr Cowdry has suggested, only the aged know the psychology of the aged; for, although we were all once young, our failure to understand the psychology of children and youths is almost universal Therefore, the plan for a series of articles on "Problems of Advancing Age" contemplates at least two on the "Philosophy of the Senescent," one by an aged man and the other by an aged woman.

These articles will not be written by persons who have suffered physical or mental misfortunes, or even by those who have been somewhat out of tune with the world, however distinguished they may have been They will be written, rather, by those who are sailing serenely into a golden sunset Benjamin Franklin in his later life could have written such an article So could Elihu Root—they need not be written by scientists Perhaps it will be found desirable to have more than one person of each sex and from different walks of life interpret for us the psychology of senescence.

Several of the articles of this series will treat of disease, not from any morbid point of view, but because a clear understanding of the hazards of life and how to avoid them is the best insurance for an eventual fullness of years Guided by scientific knowledge, the goal is useful and happy middle life and mellow old age. Perhaps those who write on "The Philosophy of Senescence" will teach us by precept and example how to live and grow old so that there will "be no moaning at the bar when I (we) put out to sea."

F R. Moulton

THE SCIENTIFIC MONTHLY

FEBRUARY, 1940

GEOLOGY AND CLIMATOLOGY FROM THE OCEAN ABYSS[1]

By DR. WILMOT H. BRADLEY
SENIOR GEOLOGIST, U. S. GEOLOGICAL SURVEY

ONE property alone of the ocean—its immensity—determines that the sediments accumulating in its great central basin shall be different from those accumulating elsewhere Most of the ocean abyss, that vast basin beyond the outer margins of the continental shelves, is too far from the land to receive more than an insignificant fraction of the finest mineral particles washed from the land by rivers and waves. Streams fill small ponds and reservoirs with mud in a comparatively few years; and rivers, by adding to their deltas, diminish the size of great inland seas such as the Mediterranean, by measurable amounts In describing the changes in the delta of the Rhone, Sir Charles Lyell wrote, "Psalmodi was an island in 815, and is now two leagues from the sea Several old lines of towers and seamarks occur at different distances from the present coast, all indicating the successive retreat of the sea, for each line has in its turn become useless to mariners; which may well be conceived, when we state that the Tower of Tignaux, erected on the shore so late as the year 1737, is already a mile remote from it" The great rivers of the world have poured many cubic miles of mud into the ocean and built huge deltas, but even the greatest of these rivers is powerless to project its muddy stream so far into the abyssal realm of the ocean as to make a significant contribution to the deposits accumulating there.

Only that part of the land waste taken into solution by running water reaches and eventually makes a permanent contribution to the deposits on the floor of the ocean abyss. Of the substances so transported calcium is dominant as a maker of oceanic sediments and silica is next By far the greater bulk of the deposits covering the abyssal parts of the North Atlantic consist of calcium carbonate and silica shells whose substance was abstracted from the sea water by small organisms However, when we consider that much of the calcium and silica brought each year to the sea are deposited on the continental shelves and in coastal waters and that only a small fraction of the annual supply reaches the deep ocean basin, we begin to realize how slow oceanic deposition must be. Studies by H Lohman and by W. Schott, both of Germany, and by the writer and other members of the Geological Survey, U. S. Department of the Interior, agree in indicating that the carpet of sediment covering the floor of the abyssal part of the ocean increases each year by the addition of a mere film of mud between one hundredth and one thousandth of an inch thick. Because of this slow rate of accumulation more earth history is compressed into a short column of such sedi-

[1] Published with the permission of the Director, Geological Survey.

ment than can be found in any shallow water or terrestrial sedimentary record. In consequence of that fact geologists have long desired access to the record written in abyssal sediments

I

Cores as much as 10 feet long of undisturbed sediment can now be successfully taken from the ocean bottom by means of an ingenious coring device designed by Dr C S Piggot of the Carnegie Geophysical Laboratory in Washington This device shoots the core barrel into the mud by means of a gun loaded with coarse pellet cannon powder This apparatus and its operation were described by Piggot in the March 1938 issue of the SCIENTIFIC MONTHLY Trials along the Atlantic coast in 1935, in water ranging from 1,200 to 7,500 feet in depth, showed that the apparatus was ready for deep-sea work Then, in May 1936, the Western Union Telegraph Company's cable ship *Lord Kelvin* stood out of Halifax bound for Falmouth, England, to repair, en route, a trans-Atlantic cable She carried as guest Dr Piggot, who had with him the coring device On that trip he took 11 cores at the stations shown in Fig 1. These cores ranged in length from 10 feet to 1 foot 1 inch and averaged 7 feet 8½ inches The very short one was short because the core barrel struck rock. At the places where these cores were taken the water ranges in depth from 4,200 feet (on the top of the mid-Atlantic ridge) to 15,840 feet. Back in the laboratory the core barrels were carefully cut open lengthwise without disturbing the sediment, so that these compact records of the past could be examined and studied with microscopes and analyzed piece by piece from as many points of view as could be devised.[2]

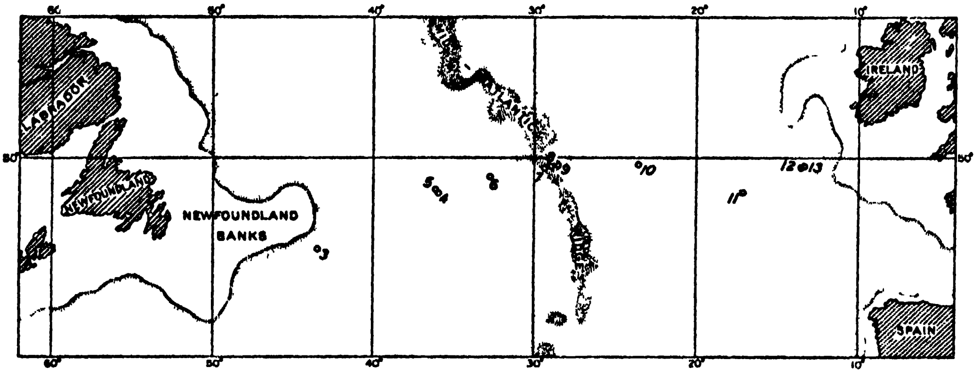


FIG. 1. CHART OF A PART OF THE NORTH ATLANTIC OCEAN SHOWING THE LOCATION OF THE DEEP-SEA CORES

In our interpretation of the deposits penetrated by these cores we have followed the principle long ago laid down by Lyell, that the present is the key to the past The sediments now accumulating on the ocean floor are therefore the standard, or norm, with which all the older sediments below must be compared. They contain the remains of the same kinds of organisms that are now living in the surface waters above and that live on the bottom mud itself They are, in short, the resultant of all the factors of the deep oceanic environment as we know them to-day.

Predominantly the modern sediments consist of the skeletal parts of minute free-floating or plankton organisms that

[2] The cores were studied by M. N. Bramlette, Jos A. Cushman, L G. Henbest, K. E Lohman, P. D Trask and the writer, all of the United States Geological Survey. In addition to these geologists, Dr. W L. Tressler, of the University of Buffalo, studied the Ostracoda, and Dr. H. A. Rehder, of the U. S. National Museum, studied the Mollusca (chiefly pteropods).

dwell in the sun-lit surface water. Most of these organisms live but a comparatively short time and then settle into the dark abyss, producing, as it were, a gentle rain of minute limy and siliceous skeletons. Thus it is that some of the dissolved substances from the land are eventually transformed by minute organisms into durable particles of lime and silica and find their way to the floor of the ocean

To be sure, not the same kind of sediment is accumulating on all parts of the ocean floor to-day. That forming in polar regions differs markedly from that forming in temperate latitudes A comparable degree of difference is also to be found between sediments formed in water less than approximately 16,000 feet deep and in water of greater depth In the consideration of these North Atlantic cores, however, we shall be concerned chiefly with only two types of oceanic sediment that are now forming—foraminiferal ooze and blue mud

At all the core stations except one, the ocean floor is carpeted with foraminiferal ooze The westernmost core was taken in the blue mud zone Because departures from these two types of sediment are the means by which we recognize changed conditions in the world of the past, it is necessary to have in mind the distinguishing features of these types. As the name implies, foraminiferal ooze is characterized by an abundance of the minute limy shells of Foraminifera—a class of unicellular animals. Most of these are the globose shells of Globigerina, Globorotalia and other similar surface-dwelling or pelagic genera. Intermingled with the pelagic forms is a lesser number of bottom-dwelling forms whose shells are more varied in both form and texture. Fragments of foraminiferal shells, ranging from nearly complete individuals down to finely comminuted particles, account for a considerable bulk of the sediment. Mixed with the comminuted shells are still finer limy particles of unknown origin and also great numbers of minute limy plates secreted by unicellular plants that live in the surface waters. These microscopic plants are brown algae belonging to the Coccolithophoridae. The commonest ones have a globular coating or shell made up of calcium carbonate plates of distinctive shapes When the plant dies the plates, which are known as coccoliths, readily separate so that in the sediment only the individual plates are found Most of these plates are less than one ten thousandth of an inch across, yet they are so numerous that locally they make up as much as 10 per cent of the sediment. Scattered through the limy constituents of the mud are the

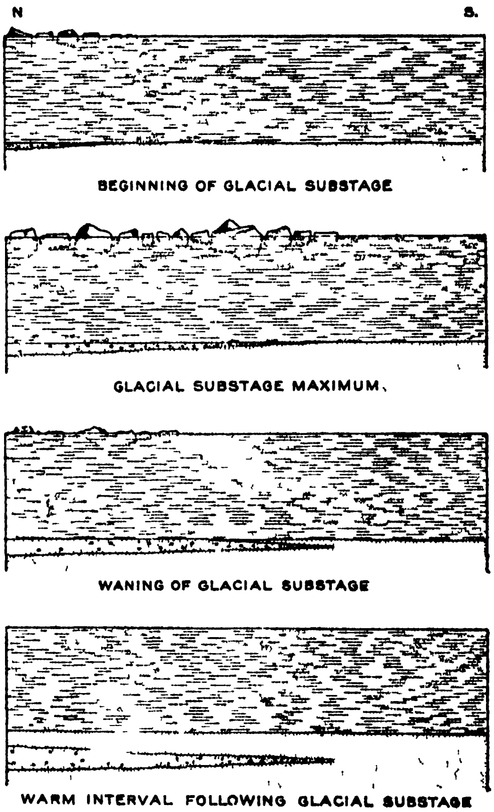


FIG. 2. DIAGRAM OF GLACIAL MARINE SEDIMENT

ILLUSTRATING THE GROWTH OF A WEDGE. COARSE STIPPLING REPRESENTS GLACIAL MARINE SEDIMENT, FINE STIPPLING REPRESENTS FORAMINIFERAL OOZE.

ornate silica skeletons of diatoms and Radiolaria. Minute clay particles from the land, motes of atmospheric dust, and, less consistently, particles of volcanic ash make up the remainder.

The blue mud that is forming near the foot of the continental shelf off the Newfoundland Banks, where the westernmost core of the series was taken, is characterized by an abundance of clay and fine silt —constituents derived from the land and continually swept off the continental shelf. This terrigenous constituent in effect dilutes the normal oceanic sediment of organic remains so that foraminiferal shells, diatom tests and the like, are less numerous per unit volume than they are in the foraminiferal ooze Blue mud zones, or belts, skirt the continents and define the limits to which considerable amounts of land waste are transported in suspension Seaward, blue mud grades gradually into foraminiferal ooze.

This then is the present-day areal distribution of these two dominant kinds of sediment in the North Atlantic; but it was not always so, for at various times in the past not only the distribution but also the kinds of deposits were different, for in these cores we have a succession of layers one above the other.

The layers differ somewhat, both in number and thickness, from one core to another but less than might be expected in cores taken so many miles apart Nevertheless, because of this variation it will be simpler to consider here the layers in a single core whose sedimentary record is both long and clearly written. The core from station 7, just west of the mid-Atlantic ridge in 10,680 feet of water, best fulfills this requirement Furthermore, this core is so nearly like most of the others that comparisons with them can easily be made

At the top of the core from station 7 is foraminiferal ooze a trifle more than one foot thick To the unaided eye it appears to be nearly homogeneous, but the microscope shows a significant departure from homogeneity. Tiny particles of volcanic ash, which are scarce at the top of the core, become progressively more numerous until at a place about 9 inches down there are one or two thin layers in which they are plentiful. Below that they are absent. The word "ash" suggests that the particles are cinder-like but instead, like most volcanic ash, they are flakes or shards of clear, gray glass—usually parts of glass bubbles that formed, and broke into bits, as the molten rock frothed up out of a volcano in an explosive eruption Such glass shards are so small and thin that they are blown far above the volcano and thence carried great distances by the wind.

The important thing, however, is that this same distribution of volcanic ash was found in all the cores except two—the very short one that struck rock and the westernmost one in the blue mud zone. This means that at one definite episode a volcano of the explosive type threw out, in a short series of eruptions, ash that settled as a thin layer extending across the North Atlantic Ocean Even allowing for the very slow settling of these particles through several miles of water, most of them must have reached the bottom within a year or two after the eruptions Thus, the base of such a layer must be very nearly contemporaneous throughout its entire extent and is, therefore, unsurpassed as a means of correlating layers of sediment from core to core.

The base of this ash layer, or zone, is not at the same position in all the cores. In some it is only a few inches from the top, in others it is near the middle, and it evidently must lie below the bottom of the westernmost core, for that core, despite its length of nearly 10 feet, has ash shards scattered sparsely all through it but no layers wherein the particles are concentrated. The layer of sediment between the base of the ash zone and the tops of the cores has, of course, all been deposited since the ash fell, and where

this layer is thick it means that there the ocean floor is being built up more rapidly than where the layer is thin. Thus, we learn that sedimentation is more than ten times as rapid in the blue mud zone off the Newfoundland Banks as it is at the site of the core just west of the mid-Atlantic ridge and that it is slowest on the crest of the mid-Atlantic ridge. The position of the ash zone in the cores also shows that, in general, sedimentation is faster in the great basin east of the mid-Atlantic ridge than it is in the basin west of the ridge

The upward scattering of the ash shards through the sediment above the base of the ash zone where they are most plentiful, is apparently a testament to the activity of mud-feeding animals that inhabit the deeps Animals like the sea cucumbers and sea urchins are voracious and indiscriminate feeders They move slowly over the mud, scoop it up, and pass it through their intestinal tracts for what nutrients it contains and, in so doing, leave the mineral particles at a slightly higher level than they were before When the volcanic ash covered the sea bottom the animals then living must have taken in mud that consisted largely of shards, but as time went on the continual rain of minute shells and other organic remains diluted the ash and so successive generations of mud feeders encountered fewer and fewer shards until now their descendants only rarely find these abrasive particles to plague them A similar, though somewhat thinner, zone containing volcanic ash was found in the lower parts of four of the cores west of the mid-Atlantic ridge.

We found no clues to aid us in locating the volcanoes that produced the ash in either zone Both the Azores and Iceland have volcanoes that could produce ash of that chemical composition; and volcanoes in either place, or elsewhere, might have been the source

Aside from the fortuitous occurrence of the volcanic ash zone, the uppermost layer of foraminiferal ooze in the representative core is virtually identical with the sediment now forming in that part of the North Atlantic. This must mean that the environment has not changed materially during that interval But lower in the core are four layers of distinctly different sediment that betoken radical changes in the oceanic environment of the past. The uppermost of these layers is approximately one foot below the top of the core and is itself approximately one foot thick. The others, which are somewhat thinner, follow in sequence below and are separated from one another by layers of foraminiferal ooze each of which is nearly a foot thick The sediment in these four layers is characterized by an abundance of silt and sand, and a sprinkling of pebbles some of which are nearly half an inch across Foraminifera shells are scarce, coccoliths are absent and the sediment as a whole is rather poor in lime

The uppermost of these sandy layers apparently extends all across the North Atlantic, for it was found just a little way below the upper ash zone in all the cores except the westernmost one and of course the very short one at core station 11. Perhaps the other three sandy layers also extend across the Atlantic, but we found them only in the cores taken at stations 4 to 8, in the western part of the ocean Of the cores taken east of the mid-Atlantic ridge only the easternmost one contains more than one sandy layer It contains one well-defined and two lower rather ill-defined layers

No marine currents, short of those fabulous ones imagined to exist in the western Atlantic by pre-Columbian sailors, could have brought from the land the sandy and gravelly material in these four layers, and certainly the ocean has not been repeatedly drained nor has its floor been repeatedly uplifted several miles so that brooks and rivers could have distributed it Floating ice seems to be the only agent capable of transporting so

much coarse detritus so far from the land We concluded, therefore, that only at a time when vast continental ice sheets spread over the land and continually pushed their edges out to sea could the ocean contain enough drift ice (particularly ice laden with coarse detritus scoured from the land) to account for the sandy and pebbly layers Such a time could have been none other than the Pleistocene ice age. We call these deposits, therefore, glacial marine deposits

This conclusion was beautifully confirmed by the study of the Foraminifera which furnish an index of surface water physical characteristics. Furthermore, the Foraminifera indicated that the sediment between the uppermost pair of glacial layers had been deposited in water nearly, or quite, as cold as the glacial deposits. In this the Foraminifera again agreed with the findings based upon the physical features, for, unlike the other non-glacial deposits, the texture of this particular sediment is intermediate between glacial and non-glacial types and it contains fewer shells than the other layers of foraminiferal ooze

We shall try now to visualize the conditions in the North Atlantic some thou-

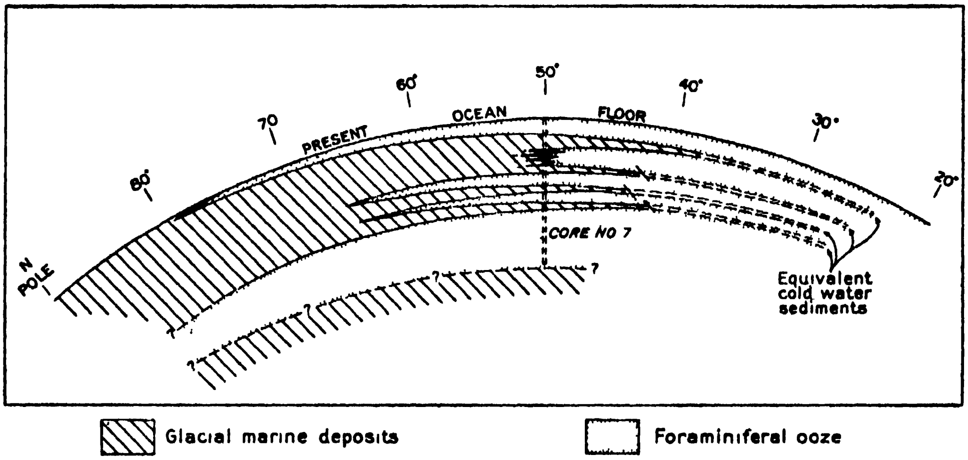


FIG. 3 DIAGRAM OF GLACIAL MARINE DEPOSITS

SHOWING THE INFERRED DISTRIBUTION ALONG A MERIDIONAL SECTION THROUGH CORE NUMBER 7. THE VERTICAL SCALE IS TREMENDOUSLY EXAGGERATED.

temperature. In the cold northern waters live comparatively few species, though individuals are numerous and their shells are robust. In the warmer waters of the Gulf Stream and the southern parts of the North Atlantic the Foraminifera are represented by a much greater number of species, including both thick and thin shelled forms. Although several species are common to both environments the assemblage of forms found in either environment is distinctive. It was found that the cold-water forms in the cores were restricted to certain zones that coincided exactly with the glacial marine layers as recognized by their

sands of years past when the glacial marine deposits were forming. We must conclude from the great areal extent of the glacial layers that the sea southward beyond the fiftieth parallel of latitude contained much berg ice from continental glaciers and doubtless also much shore and sea ice During glacial epochs the sea level goes down because much of the water that falls on the land as rain or snow is converted to ice and remains locked up in the vast ice sheets that spread over the land. It has been estimated, first by Antevs and later by Daly, that during the last glacial stage the sea level was approximately 300 feet below

its present position. Probably extensive shoal-water platforms furnished large volumes of sand, gravel, and other detritus not only to the glacier ice shoved out across them but also to grounded sea ice

Drawing a comparison with conditions as they now exist in both polar seas, we may infer that the drift ice did not form a close pack or continuous sheet over the site of the cores but instead was broken and probably melting rather actively, for the glacial marine zones contain some pelagic Foraminifera and diatoms that must have lived in open water Such Foraminifera and diatoms are rare or absent from the bottom deposits beneath the continuous sheets of pack-ice in both the Arctic and Antarctic

Active melting of the drift ice at essentially its southern limit in this part of the North Atlantic may well have been due to the Gulf Stream, which probably flowed there much as it does to-day but with somewhat less volume and less heat during the glacial maxima. A warm current meeting extensive areas of drift ice offers optimal conditions for the growth of pelagic organisms. The cold polar water, long stored in the dark under the ice, becomes rich in dissolved phosphates, nitrates, oxygen and probably also silica, because the few organisms that live there fail to use up these substances With these nutrient substances available in generous amounts the indigenous plankton and also some of the pelagic organisms carried up from more temperate latitudes by the warm current thrive in great abundance. Many kinds of the warmer-water forms are killed off when they reach the polar water and these go at once to the bottom to become part of the sediment

The convergence of a warm northward-pushing current upon the cold water of a berg-dotted sea provides a mechanism that readily accounts for a rather abrupt transition between the glacial marine deposits and the overlying and underlying foraminiferal ooze with its relatively warm-water fauna. As the areas of pack ice and bergs expanded southward glacial marine sediments began to accumulate where, not long before, the remains of warm-water pelagic organisms had been accumulating. So also, when the southern limit of the floating ice retreated the warm current followed it northward, showering the top of the glacial marine sediment layer with warmer-water Foraminifera and coccoliths. This mechanism is illustrated diagramatically in Fig 2 Two significant inferences may be drawn from this diagram, the first is that the process is a continuously recording one; the second is that in cross section the layers of glacial marine sediment are wedge-shaped, thinning out and disappearing southward and thickening northward. The layer of foraminiferal ooze that overlies the uppermost glacial marine layer in the cores apparently must wedge out if it is traced far enough northward because a fine-grained type of glacial marine sediment is now forming in the polar region and, for all we know, has been accumulating there continuously since the last glacial epoch Traced southward from the latitude of the cores the glacial marine zones should wedge out or grade out into another type of cool-water deposit—perhaps red clay or foraminiferal marl containing a cool-water fauna. It is suggested by Schott's recent work on the Foraminifera from the cores taken on the *Meteor* expedition (1925–1927) that the uppermost glacial marine zone of the Piggot cores may be represented in the equatorial Atlantic by a zone of sediment containing Foraminifera that indicate cooler surface water than now exists in the same locality. Schott interprets this zone as probably the tropical equivalent of the last glacial maximum

This inferred distribution of the glacial marine zones in a hypothetical cross section of the sea floor along a meridian in the western part of the Atlantic between

latitude 20° and the north pole is shown graphically in Fig 3 Only the study of additional cores that may be taken in the future can show how near or far from correct is this inference

More than ordinary interest attaches to the interpretation of the glacial marine zones of these cores, because cores of ocean bottom sediments of this length and longer open a new approach to the study of glacial epochs. One of the first questions that arises is how much of the whole Pleistocene or glacial epoch do the glacial marine layers in the cores represent? On the land the history of the Pleistocene has been divided into several major glacial stages separated by warmer interglacial stages and each stage has been divided into substages

We know that the whole Pleistocene epoch, which embraces four or more major glacial stages, lasted something like a million years or more Antevs has estimated from his study of certain annually stratified or varved glacial sediments that the last ice sheet disappeared from North America only 10 to 15 thousand years ago This interval since the last ice sheet disappeared is known as the postglacial interval. The postglacial sediment in these cores is that which overlies the uppermost glacial marine zone In the four cores west of the mid-Atlantic ridge that contain four glacial layers the postglacial sediment averages only a little more than one foot in thickness This means that only that much sediment has accumulated on the ocean floor in the past 10 or 15 thousand years. Then, if we make the reasonable assumption that the other sediment in these cores accumulated at a roughly comparable rate, it would mean that a 10-foot core represented probably not more than 150,000 years Even allowing for large errors this seems rather clearly to be too short a time for the whole Pleistocene epoch. Consequently, we concluded that the four glacial marine layers in the cores more likely represent glacial substages of the last major stage.

One more bit of evidence suggesting that this is the more probable interpretation can be inferred from the sediment in the lower part of core number 7. Below the lowest glacial layer in this core is a layer of chalky sediment more than 3 feet thick that consists almost wholly of foraminiferal shells. But the intriguing thing is that the Foraminifera indicate water temperatures as high as, or higher than, those that prevail in that part of the Atlantic to-day Here then is a layer that represents a climate as warm as, or perhaps somewhat warmer than, the present and, moreover, if the thickness of the layer means anything, a period of warm climate that persisted for perhaps three (or more?) times longer than all postglacial time Such a long, warm interval suggests a major interglacial epoch, that is, an epoch between two major glacial stages

I can not refrain, however, from commenting here on a highly speculative inference that one might draw from the interpretation suggested in the preceding paragraphs That is, the composition, texture and thickness of postglacial sediment in the cores is more closely analogous to the sediment representing the intervals that separate glacial substages than it is to the much thicker layer of sediment that represents the last major interglacial stage. This raises the question whether we may not be living in one of those intervals that separate glacial substages rather than in a true interglacial epoch? The temptation to pursue this idea and perhaps be confronted with having to make a prognostication is effectively curbed by the recollection of Mark Twain's observation that "There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact."

Nevertheless, it seems to me that much could be learned from systematic coring and mapping of these interfingering wedges of glacial marine and warmer-water foraminiferal sediments. The

southern edges of the glacial deposits and the northern feather edges of the warmer-water deposits should, by comparison with the present ice limits and present climate, serve as reasonably good measures of the intensity of climatic changes that produced glaciation and deglaciation, or at least partial deglaciation. Also, the relative duration of these climatic pulses could be learned from the oceanic sedimentation because that process is a continuous and fairly regular one Furthermore, adequate sub-oceanic maps of the southern edges of glacial marine deposits should enable us to draw pretty fair maps of the Gulf Stream across the greater part of the North Atlantic during the glacial maxima Such charts of the Gulf Stream's deflected course might enable climatologists to reconstruct more fully and more accurately the climate of western Europe during the glacial maxima. A knowledge of the relative intensity and duration of these alternating cold and warm epochs might conceivably throw light on the migrations and cultural development of pre-historic peoples in Europe.

Submarine volcanic activity is suggested by the shortest and the longest cores of the group (numbers 10 and 11 of Fig 1) The shortest core (number 11) is only 13 inches long The upper 6 inches consists of limy foraminiferal ooze like that on the floor of most of the North Atlantic Ocean Below this ooze is a light-colored, clayey mass that contains nodular lumps of the volcanic rock, basalt These lumps of basalt are deeply altered—their constituent minerals have undergone a chemical change that deprived them of their original hardness, lustre and sharply angular form and reduced them to an aggregate consisting largely of minute flaky or micaceous mineral particles of clay The intensity of the alteration diminishes inward toward the centers of the lumps so that their centers are composed of comparatively hard rock. At the bottom of the core, however, the rock is only moderately altered and therefore so hard that it stopped the core bit despite its very considerable velocity

The clayey mass in which the basalt lumps are embedded resembles in texture and mineral composition the thin alteration rims found on the surfaces of small pieces of basaltic pumice and basaltic glass scattered through several of the other cores This suggests that most of the clayey mass was once basaltic glass that formed by solidification of the lava when it came in contact with the sea water Lava of that composition if cooled very slowly crystallizes and becomes a rock composed of an aggregate of interlocking crystals Now because the upper surface of the clayey mass has numerous small cavities or vesicles that closely resemble the vesicular surface of certain lava flows, because the clay contains lumps of basalt, and finally, because, at the base of the core, the basalt is comparatively fresh we suggest that this core may have struck a lava flow which, several thousand years ago, was extruded on the ocean floor—a lava flow that in coming in contact with the cold sea water was chilled to a glass on the outer part Doubtless the glass cracked and tended to shatter but presumably the continual flow of heat from the intensely hot interior kept the glass partly plastic for a long time

Another observation that lends support to the hypothesis that the rock encountered is part of a submarine lava flow, is that the upper part of the clayey mass contains scattered grains of sand and Foraminifera shells Our inference is that the turbulent water around the edge of the lava flow carried these things up from the sea bottom as the lava front advanced and dropped them into cracks and hollows on the lava surface so that they were, in effect, incorporated in the upper part of the glassy mass. More significant, however, is the fact that the original calcium carbonate of these occluded Foraminifera shells has been converted to another mineral—a silicate that

is probably the mineral phillipsite. Now phillipsite, although it has been found as well-formed crystals in deep-sea oozes, has not, so far as we are aware, been found replacing foraminiferal shells. On the other hand, phillipsite has been found in basaltic rocks in many parts of the world. It appears from all this that the chemical transformation from calcium carbonate to the silicate mineral was engendered by the exhalation of heat and hot solutions from the lava. It also appears to us that the thick mass of clayey material surrounding the basalt fragments must have been produced at an accelerated rate by the heat from the lava, as the small pieces of basaltic glass in other cores have only thin coatings of clayey material and imply that under normal conditions chemical reaction between (cold) sea water and basaltic glass takes place very slowly.

One more bit of evidence was found that also fits in with the hypothesis that the rock struck by this short core is a part of a submarine lava flow. Not a single shard of volcanic glass was found in the foraminiferal ooze overlying the clayey mass and basalt, whereas in all the other cores the shards are scattered through the upper parts, and sparsely, all the way to the tops It may sound paradoxical to regard the absence of volcanic ash as suggestive evidence for a submarine lava flow, but the paradox disappears when we know that the shards of volcanic glass found in the upper parts of the other cores have a distinctly different chemical composition from that of basalt and that they could not, therefore, have been derived from a volcanic vent that was extruding basaltic lava. Our tentative interpretation is that the basaltic lava spreading over the sea floor at the site of core 11 sealed beneath it the sediment containing the scattered shards of volcanic glass so that they could not in any way be reworked into the later sediment that accumulated on top of the lava flow Were this rock simply a boulder that had been dropped there by an iceberg it seems probable that successive generations of bottom-feeding animals would have worked some shards up into the uppermost sediment at this core station as they apparently did at all the others

After all, however, we must bear in mind that this short core represents only a single point in the ocean abyss and, despite the fact that it contains several mutually consistent bits of evidence that the rock it encountered is part of a submarine lava flow, it will require several more cores in that immediate vicinity before the existence or non-existence of such a flow can be definitely established. There still remains the possibility that the rock encountered is the upper part of a very large boulder of basalt that was dropped there by an iceberg and that, by reason of the size, this upper part for a long time projected above the sea floor. Very long exposure to the sea water might have produced its deep alteration zone of clay. This interpretation, however, apparently leaves unexplained both the conversion of the foraminiferal shells to a silicate mineral and the absence of volcanic ash shards from the sediment that covers the rock; furthermore, the large boulders that have been dredged from the deep parts of the ocean, although not of rock types that are so readily altered, have been remarkably little affected by their stay in Davy Jones's locker.

The longest core of the group, number 10, is quite as anomalous as is the shortest core It was taken several hundred miles west of the shortest core in 13,780 feet of water. At this station the coring device buried itself and an unknown amount of soft mud was lost out the top of the core barrel. However, we know from sediment that stuck to the ship's anchor flukes that the sea floor at this station is covered with normal foraminiferal ooze. This core, which is the full 10 feet in length, contains two zones of

highly distinctive mud—a homogeneous, very fine-grained, dark gray mud that shrank greatly upon drying. At the bottom of the core is a little more than 3 feet of this mud and at the top is another zone of it a little less than 3 feet thick (plus some more that was lost out at the top of the coring device) Between these two zones is normal foraminiferal ooze and glacial marine sediment

These two relatively thick mud zones differ from all the sediment in the other cores in composition and content of organic remains The mud in these zones consists of a mixture of minute clay particles and almost equally minute particles of basaltic glass and of the constituent minerals of basalt The glass and mineral particles of basaltic composition make up approximately half of the mud. Foraminifera shells and the limy parts of other organisms are exceedingly rare or absent except in the upper part of each zone, where they become progressively so much more plentiful that mud of each zone grades upward into normal foraminiferal ooze The abundance of basaltic mineral particles and fresh basaltic glass point to a volcanic source for much of the material and the scarcity of foraminiferal shells and coccoliths suggests that the peculiar mud accumulated in so short an interval that only a very few of these organic constituents reached the bottom.

Basaltic particles, comparable with those just described, presumably were discharged into the water of the Mediterranean over the Nerita Bank off the coast of Sicily during the submarine eruption of 1831, for according to H S Washington's account, "... the surface of the sea was seen to rise to a height of 80 feet, the column maintaining itself for 10 minutes, and then again sinking down This was repeated every quarter to half an hour, and was accompanied by a dense cloud of black smoke and loud rumblings." The black smoke presumably consisted of basaltic dust particles. Other submarine volcanic eruptions have been observed in various parts of the world, notably in the Strait of Sunda off the coast of Java, but, of course, all in comparatively shallow water. It is our belief that two submarine volcanic eruptions on the ocean floor gave rise to the two zones or layers of basaltic mud in core 10. Such eruptions at great depths would presumably have no perceptible effects at the ocean's surface.

The volcanic vent from which this material came, however, apparently was not close to the site of this core This is inferred from the fact that the clay and basaltic particles in the greater part of each mud zone make up a homogeneous mixture No gradation in size of particles from large at the bottom to fine at the top is discernible. Had the material been thrown violently into suspension as a great cloud near the site of this core the particles would surely have fallen into a well-graded sequence with the heavier basaltic particles at the bottom and the minute flaky particles of clay above As they are not so arranged we might speculate that the volcanic eruptions occurred at some distance from core 10 One possible interpretation is that submarine volcanic eruptions discharged finely divided basaltic particles into the sea and at the same time threw into suspension much clay derived largely from the deeply altered surface of earlier submarine lava flows Such a mixture of material, having settled to the bottom, would, by reason of its fine grain, make a quite labile sediment that would flow readily, even on a gently sloping surface, and so would tend to collect in the hollows and deeper depressions on the sea floor Our speculation is that the basaltic mud moved to the site of core 10 as submarine mud flows that resulted from more or less remote submarine volcanic eruptions The gradation upward from basaltic mud into the overlying foraminiferal ooze we may attribute to the incessant work of mud-feeding animals

that subsequently established themselves on the surface of the mud flows. Indeed, in the upper part of the upper basaltic mud layer of core 10 there are numerous mud-filled burrows, tubes and coprolitic lumps that evidently were made by mud-dwelling animals.

III

Certain purely geologic evidence found in these cores may be of significance for physical oceanographers in their study of the circulation and dynamics of ocean water masses As revealed by these few cores, currents apparently move rather rapidly across the crest of the mid-Atlantic ridge There, nearly all the finest mineral particles, the smallest shells and diatoms, and the lightest shards of volcanic glass have been swept away, leaving the heaviest foraminiferal and pteropod shells and the coarse sand The mid-Atlantic ridge is a veritable mountain chain that extends southward from Iceland through both North and South Atlantic Oceans dividing them longitudinally into two approximately equal basins Where the line of these cores crosses the ridge it is known as the Farady Hills. These rise about 8,000 feet above the general level of the ocean bottom on either side, yet their tops are 4,200 feet below the ocean surface Perhaps this great ridge accelerates the flow across it by constricting the cross section of a large volume of slowly moving water

The next core east of the mid-Atlantic ridge contains, in contrast with all the other cores, a great abundance of small diatoms, coccoliths, minute shards of volcanic ash and clay particles The abundance of these in this deeper-water core, their absence from the core on the ridge and the entirely normal texture of the core just west of the ridge suggest, but do not prove, that the current moves across the ridge from west to east. More cores in the vicinity of the ridge are necessary to demonstrate whether or not this interpretation of current direction is valid

Currents of comparable velocity move across the outer edge of the continental shelf off the southwest coast of Ireland. The easternmost core of the series taken there in water 6,420 feet deep consists predominantly of large foraminiferal shells and coarse sand and gravel It resembles rather closely the core taken on the top of the mid-Atlantic ridge and, to geologists, the explanation for the texture of both must be the same We know of no other agent than currents of water that will so effectively winnow out the fine from the coarse in bottom sediments

Having looked a little way into the past that has been revealed by this exploratory series of North Atlantic deep-sea cores, we may now look ahead and consider what sort of information is to be expected from the long-core method of studying sediments not otherwise accessible Although information that may be obtained from deep-sea cores will perhaps be used primarily for geological and geochemical investigations, it seems that the method has a broader scope and may yield data that are of value to climatologists and archeologists Pelagic or surface-dwelling Foraminifera, as contrasted with those that live in the abyssal deeps, are reliable indicators of surface-water temperature and therefore, indirectly, of warm or cold climate Obviously, however, their usefulness is restricted to the thermal element of climate for they can tell us nothing of the wetness or dryness of an epoch. Significant evidence bearing on postglacial climatic changes might be obtained from detailed study of the Foraminifera in cores taken in parts of the ocean where postglacial sedimentation has been comparatively rapid as, for example, near the seaward edge of the blue mud zone. In this zone, or belt, sedimentation is more rapid than it is farther seaward because it receives considerable clay from the land in addition to the normal sup-

ply of the remains of pelagic organisms. The object of selecting the seaward edge of the blue mud zone for this kind of investigation is to strike places where the postglacial sediment is as nearly as possible of the same thickness as the total length of the cores On the assumption that the sediment near the seaward edge of the blue-mud zone accumulates at an essentially uniform rate, the climatic fluctuations found would be approximately located in time within the postglacial interval It is conceivable that by such a method climatic fluctuations could be correlated from place to place along the ocean margins from the Arctic to temperate or even tropical latitudes and perhaps also from continent to continent

Long cores of sediment from the shallower straits between continents and islands may perhaps yield reliable evidence of former land bridges One might, for example, anticipate finding swamp deposits or other similar features below marine sediments in cores taken in the shallow waters of Bering Strait.

Cores of the deep-water sediments in the Mediterranean Sea should contain an unusual amount of information because the peculiar hydrography of the Mediterranean makes it rather sensitive to climatic changes and because the Mediterranean region is one of volcanic and seismic activity

The pelagic fauna of the Mediterranean was presumably quite different at the end of the last glacial stage because of the greater volume of fresh or feebly saline water that flooded its surface The more or less gradual change from that condition to the present hydrographic condition should be marked in the sediments, especially of the western basin, by the appearance of generally Atlantic types of coccoliths, pteropods and Foraminifera which inhabit the surface waters now Indeed, these forms may have reached a recognizable peak of abundance during the higher sea level of the "climatic optimum." At some level, perhaps corresponding to late Neolithic time, when, according to Sandford and Arkell, northern Egypt became desert, the wind-blown sand from the region south of the Mediterranean should begin to make its appearance This wind-blown sand is abundant in the sediments forming to-day in the deep basins of the Mediterranean

Less vague, however, would be the record left by the activity of explosive volcanoes A considerable number of these ash falls in the upper part of the post-Pleistocene column of sediments should be correlatable with human history Earthquakes, too, should have caused submarine mud slumps that threw into suspension much sediment which settled as wide-spread blankets of distinctive sediment Such a blanket of sediment should show a gradation in grain size owing to the differential settling rates of the constituent particles thus thrown temporarily into suspension.

It seems probable, therefore, that long cores of the sediments in the deep basins of the Mediterranean would reveal an extraordinarily rich and varied record in a locality critical not only by reason of the unusual configuration of the basin but also by reason of the wealth of information that is already available from the long historic records, the archeology and the Pleistocene and post-Pleistocene geology.

The long cores from the North Atlantic, which penetrated older oceanic strata than have ever before been brought up from the deeps, are, in a sense, pioneers in a new and vast field of oceanic geology Their study has revealed fragments of late geologic history that we may expect to be enlarged and fused into a composite whole as more and more cores are taken in systematic surveys of the ocean floor. So vast is this field to be explored that the cores already studied are but pin points of light in an abyss of darkness

WILLIAM BARTON ROGERS, PIONEER AMERICAN SCIENTIST

By Dr. ARTHUR BEVAN
STATE GEOLOGIST OF VIRGINIA

William Barton Rogers was a pioneer American scientist, living during the third century of the American colonization. During the span of his life, 1804–1882, he made fundamental investigations and discoveries in his chosen field of geology and he pioneered in other fields. He was also a lucid and inspiring teacher, an eloquent and captivating public lecturer and a sagacious and masterly organizer and administrator. In him were combined the qualities of a pleasing personality, devotion to pure and practical science and a zeal for effective public service

To Virginians and others, his life will be of perpetual interest because he organized the first official geological survey in the Commonwealth, produced its notable accomplishments almost single-handed, and made lasting contributions to the historic achievements of the College of William and Mary and the University of Virginia By scientists and engineers everywhere he will be venerated for the practical fruition of his vision of the Massachusetts Institute of Technology By members of the American Association for the Advancement of Science—present and future, scientists and laymen—he will be esteemed as one of its founders and principal leaders He will also be remembered as one of the early presidents of the Association, and he was the third president of the National Academy of Science.

To evaluate the accomplishments of Rogers as a geologist, it will be helpful to review briefly conditions in his time from various points of view: One should have in mind the state of geology then as a science and its public status in Virginia and elsewhere, the difficulties with which Rogers had to cope in pursuing his researches and performing his official tasks; and his coordinate activities as an educator, organizer and administrator, because the manifold activities of the versatile man were closely related. The immediate ancestry, home training and education of Rogers had also an important directive influence upon his productive life The stage upon which he moved was constantly changing, but he created opportunities and used his talents to develop them for the general welfare

Sketch of Life

William Barton Rogers was born in 1804 in Philadelphia of Scotch-Irish parentage, his father having been expatriated from Ireland. His father became a physician before William was born and continued to practice medicine until he was appointed in 1819 to the chair of chemistry and physics at the College of William and Mary in Virginia. Here, William received his college education The classics, chemistry, mathematics and natural philosophy were his chief fields of study, but he is said to have excelled especially in mathematics His father, apparently gifted as a teacher and with an absorbing interest in the education of young men, imparted much knowledge and wisdom to his sons. William's own talents and ability soon became so evident that at the age of twenty-three years he was lecturing in

Baltimore on natural science and teaching natural philosophy at the Maryland Institute in Baltimore. Then for seven years he taught chemistry and natural philosophy at the College of William and Mary as successor to his father, following which he was appointed to the chair of natural philosophy at the ten-year-old University of Virginia John Stewart Bryan, president of the College of William and Mary, states that "his wide and practical imagination was displayed [at William and Mary] by his insistence that something be done for the study of geology in Virginia " In 1833 he was elected a correspondent of the Academy of Natural Sciences in Philadelphia. He was thirty-one years old when he became, in 1835, the first state geologist of Virginia. In 1853 he moved to Boston, where after some time he organized what is now the Massachusetts Institute of Technology.

Influence of Henry D Rogers

William's brother Henry, who was four years younger, at the age of twenty-five years, in 1833, was elected a fellow of the Geological Society of London. During a year in London, Henry associated with the leaders—and they were giants—in British science, and kept William informed about the progress there in the development of the new science of geology Soon after Henry's return to the United States, the brothers began jointly field studies in the Appalachian region. In 1835, the year that William came to Charlottesville, Henry was appointed professor of geology and mineralogy at the University of Pennsylvania and also chief of the newly organized state geological survey of New Jersey. A year later he was also placed in charge of the first geological survey of Pennsylvania In these positions, with concurrent tenure through 1839, he made epochal contributions to the analysis and interpretation of the complex structure and stratigraphy of the northern Appalachian region. William, in Virginia, participated in some of these far-reaching investigations. Thus the scientific and official careers of these two gifted brothers were for several years developing along closely parallel lines of mutual interest and work.

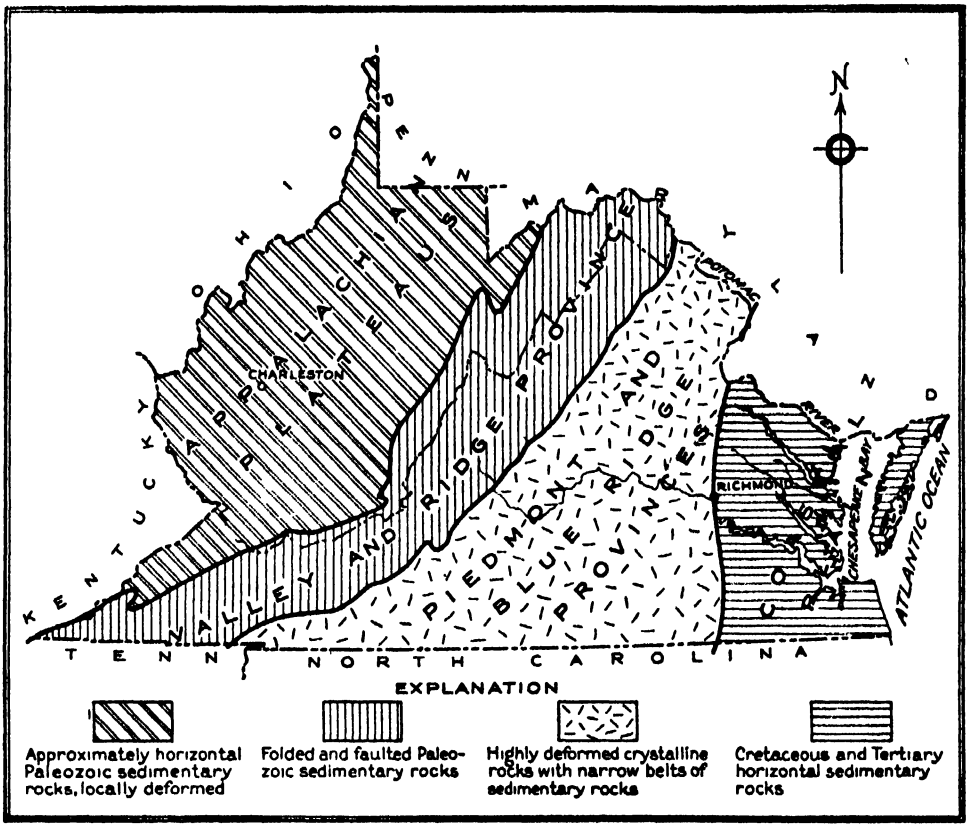
Geology in Great Britain

Henry D Rogers' visit in England was at a time of revolutionary developments in geological theories Numerous surmises of surprising accuracy about geolgic phenomena had been made now and then during the centuries prior to 1800, but sound observations and correct interpretations were relatively rare among all the speculations, many of which were essentially fortuitous As stated by Geikie,[1] a turning point in geological observations and theories was reached when James Hutton, a Scottish chemist, physician and gentleman farmer, after years of careful observation of earth features in many regions, aided in the founding of the Royal Society of Edinburgh in 1783. Two years later he presented before the society his "Theory of the Earth " In amplified form, this monumental work was published in 1795, but it remained almost unknown until cogently interpreted by Playfair, in 1802, in his classic "Illustrations of the Huttonian Theory of the Earth " Because of the "precision of statement and felicity of language" that made Playfair's volume without "superior in English scientific literature," this work soon came to be regarded as the foundation of English geology.

Playfair's treatise was being widely read at the time the Rogers brothers were receiving their education and acquiring their tastes for careers in natural philosophy and geology. Further stimula-

[1] Sir Archibald Geikie, "The Founders of Geology," p. 295. New York, 1905.

tion no doubt was afforded by the publication in 1830—when William was 26 years old—of Lyell's epochal "Principles of Geology," soon to become the textbook par excellence in geology throughout the English-speaking part of the world. It was also destined to be widely read and used for many decades Through it, many geologists became indoctrinated with a cardinal principle of geologic philosophy—that the present is the key to the past.



THE VIRGINIAS IN ROGERS' TIME

THE AREA MAPPED BY ROGERS COVERED ABOUT 65,000 SQUARE MILES AND LIES IN FIVE GEOLOGIC PROVINCES, CONTAINING A GREAT VARIETY OF GEOLOGIC FORMATIONS AND STRUCTURES.

Geology in the United States

The stage upon which the Rogers brothers together played their roles as leaders in a sphere of scientific thought was very different from that of recent decades, or even the major part of the century since William Barton Rogers made the first official survey of Virginia's geology and mineral resources. Although the guiding philosophy of geology was being formulated in Europe and the early steps in its application to the American scene were in progress, "none of the sciences was taught in the colleges and other institutions of learning in America or England"[2] at the time of Rogers' birth Merrill has stated also that "the general trend of public opinion was decidedly against the study of geology."

[2] G P. Merrill, "The First One Hundred Years of American Geology," p. 23. Yale University Press, 1924.

Jefferson, Silliman, Mitchell and others were nonetheless making at that time definite contributions to the science of geology in the United States. Several books—textbooks and others—and geologic maps had been published during Rogers' formative years by such aggressive pioneers as MacClure, Cleaveland, Eaton, Schoolcraft, Hitchcock, Emmons, Hayden and a few others. Less than a dozen articles had been published on the geology of Virginia by the time Rogers really became interested in it. Most of them described conspicuous local features, such as the Natural Bridge, the Natural Tunnel and a part of the Richmond coal basin. Still earlier Jefferson had stimulated some interest in the geology of Virginia by his paleontologic studies, continued even during his executive career. His report[1] on the discovery of gold added to the local enthusiasm. Discussions of regional problems or fundamental principles of interpretation, however, were still lacking.

—J. K. Roberts

SHELL BED IN YORKTOWN FORMATION

A FAMOUS COLLECTING PLACE FOR TERTIARY FOSSILS ALONG YORK RIVER BELOW YORKTOWN

Rogers had published several scientific papers before he was appointed state geologist and professor of natural philosophy at the University of Virginia. His interest in geology was first publicly evinced by a paper on artesian wells that appeared in 1834 in the "Farmer's Register" of Richmond. He discussed such topics as greensand, analyses of shells and calcareous marl, in all of which he gave evidence of great ability in making broad generalizations from observations.

Early Geological Surveys

It is not recorded just when some one first publicly advocated the need of an official geological survey to determine the basic geologic conditions in a particular state and to aid in the development of its natural resources. The idea, however, was the natural and inevitable outcome of the extensive private field investi-

[1] Thomas Jefferson, "Notes on the State of Virginia," 1786.

NARROWS OF NEW RIVER IN GILES COUNTY, VIRGINIA

A TYPICAL GORGE CUT THROUGH THE WESTERN RIDGES OF THE VALLEY AND RIDGE PROVINCE

gations in the seaboard states By 1830 significant work, pregnant with possibilities, was in progress, particularly in New York State, New England, Canada, North Carolina, Tennessee and Virginia

The North Carolina State Board of Agriculture, in 1823, authorized the making of a geological survey of the state, as a result of which a report was published in 1824 Another early attempt to establish an official state geological survey was made in 1824, when the General Assembly of South Carolina appropriated $1,000 for the "salary of the Professor of Geology and Mineralogy and $500 for making a geological and mineralogical tour during the recess of the college, and furnishing specimens of the same" It has been said that little of importance resulted from this venture but a report on it was published in 1826 in the newspapers of the state Eaton's survey of Rensselaer County, New York, in 1821, was, according to Merrill, "the first sufficiently thorough and systematic survey to be dignified as a geological survey," but that work was done with private funds

The decade 1830–1839 was most important in official investigations by states of the geology and mineral resources within their respective borders. During that period, fifteen state geological surveys were organized first in Massachusetts, then in Tennessee and Maryland, prior to 1835, when the first geological survey of Virginia was authorized

The Virginia Historical and Philosophical Society, of which John Marshall was the first president, was established in 1831 Among its objectives was the development of the agricultural resources and the study of the geology of the state Gold mining from 1829 or slightly earlier no doubt gave impetus to the movement to survey the mineral resources Coal had been mined in the Richmond basin for three-fourths of a century Peter A Browne, corresponding secretary of the Geological Society of Pennsylvania, in 1833 wrote from Philadelphia, urging consideration by Governor Floyd of the importance of establishing a geological survey in Virgina. W B Rogers, then a professor in the College of William and Mary, was an

CHARACTERISTIC TOPOGRAPHY IN VALLEY AND RIDGE PROVINCE
A REGION OF VALLEYS AND HEAVILY WOODED RIDGES, LITTLE SETTLED IN ROGERS' TIME

— Rhodes

RUGGED BLUE RIDGE IN SHENANDOAH NATIONAL PARK
A REGION OF COMPLEX GEOLOGY ALMOST INACCESSIBLE IN THE TIME OF ROGERS, BUT MAPPED BY HIM

ardent advocate of the step In this letter to Governor Floyd, Mr Browne wrote many such stirring sentences as, "In the beautiful and flourishing city of Richmond, I observed the fronts of two stores fitted in the new and fashionable style with granite (so called), (sienite) from Massachusetts, while there exists in the James River and on its banks, in the immediate vicinity of the town, rocks of a superior quality, in quantities amply sufficient to build a dozen cities "

Governor Floyd in his message to the General Assembly, among other reasons for a geological survey, stated, "It is well known that Virginia affords, perhaps, the most extensive mines of iron of any other country of the same extent, and fine specimens also of gold, lead, copper, plaster of paris or gypsum, and fine inexhaustible mines of bituminous coal . . " It should be noted that the enormous deposits of coal in the western part of Virginia, then including West Virginia, had not yet been discovered

The act of the General Assembly, passed on March 6, 1835, provided for the appointment of " a suitable person to make a geological reconnaissance of the State and to report to the next general assembly a plan for the prosecution of a geological survey of the State " William Barton Rogers, professor of chemistry and natural philosophy at the College of William and Mary, was selected as the "suitable person" to formulate plans and to inaugurate the new enterprise

Rogers as State Geologist

Rogers went to work soon after his appointment to survey carefully and thoroughly all of the Virginias, then embracing about 64,500 square miles It is doubtful whether even those who have reconnoitered in untraversed lands can

WARM SPRINGS VALLEY, VIRGINIA

A LONG, NARROW LIMESTONE VALLEY ERODED IN A LARGE ANTICLINE, FLANKED BY SHARP SANDSTONE RIDGES

fully appreciate the manifold handicaps, some almost insuperable, under which Rogers labored and triumphed. His "clear and penetrating intellect, ... ready and retentive memory, ... sound judgment, ... observant eye, rich and soaring imagination," and habits of "painstaking thoroughness ... even in matters of seemingly insignificant detail" equipped him well for a pioneer understanding of such magnitude.

Rogers had no real base maps upon which to plot his observed data or to guide him in the field—not even the "old reconnaissance topographic maps" which we are prone to decry in this age of accurate large-scale maps showing details of the terrain. His assistants were untrained, but being sharp observers of natural phenomena he coached them into useful helpers. Transportation was slow and arduous, for much of the terrain was rugged and a large part of the vast territory was unsettled, uncharted and unknown. Overshadowing all, was the factor of limited time—only six years eventually available by annual appointments to survey almost 65,000 square miles during the time that could be spared from exacting professorial duties at the University of Virginia.

In the face of conditions that might well make a geologist of today, with all modern facilities, pause for ample consideration before accepting such an assignment, Rogers went to work so assiduously that he was able to submit material for seven annual reports before the appropriations ceased. He prepared also much of the data for a large geologic map of the Virginias, accompanied by ninety-six detailed structure sections which were published in 1884, with a small-scale generalized geologic map of the Virginias that Rogers had once made for Major Jed Hotchkiss, of Staunton, Va.—all appear-

ing in a posthumous reprint of the annual reports[4] Rogers had thought for a long time after the Geological Survey was discontinued that funds would be provided for the publication of a comprehensive final report, including his original geologic map Hence, the brevity and general character of the annual reports should not be too critically judged But, as Merrill states, they "are all there is to show for years of careful and patient work under most adverse circumstances" the widely expanded floor of an ancient ocean Massanutten Mountain, the bold medial "range" lengthwise of northern Shenandoah Valley, was recognized as being a great synclinal tract resting in a trough of shale—an observation that has been improved only in regard to details

Rogers also observed "the extraordinary phenomenon of inversion" along North Mountain, at the northwest side of Shenandoah Valley, whereby the beds apparently are conformable but in reversed stratigraphic position He cooperated with brother Henry in preparing, in 1842, a most important descriptive paper "On the physical structure of the Appalachian chain" Merrill stated that "this work, so far as it related to the structure of the chain, has been improved upon in recent times only by the discovery of enormous overthrust faults in the southwestern portions" In the same year William read a paper on thermal springs in Virginia in which the geologic environment of many of the springs was correctly interpreted

BURKES GARDEN IN SOUTHWESTERN VIRGINIA
A BROAD SECLUDED BASIN ERODED ON LIMESTONE, ENCIRCLED BY HIGH SANDSTONE RIDGES

Geologic Contributions

Rogers made the first classification of the Paleozoic sedimentary rocks, some 40,000 feet thick, west of the Blue Ridge in Virginia, dividing these strata into fourteen groups which he designated by Roman numerals He inferred from the conformity of strata and their succession and general physical characteristics that they were part of a great series of formations that had accumulated over

[4] A reprint of annual reports and other papers on the geology of the Virginias, by the late William Barton Rogers, New York, 1884

THE IRON GATE ARCH, ALLEGHANY COUNTY, VIRGINIA

JACKSON RIVER HERE HAS CUT ACROSS A LARGE ANTICLINE IN SILURIAN SANDSTONE

SHENANDOAH VALLEY, VIRGINIA

LOOKING ACROSS THE EASTERN HALF OF THE VALLEY BETWEEN THE BLUE RIDGE IN THE FOREGROUND AND MASSANUTTEN MOUNTAIN. THE VALLEY FLOOR IS PART OF AN EXTENSIVE PENEPLAIN

Bailey Willis has recently characterized the work of Henry and William Rogers on structure thus "The Appalachian structure was fully described in a manner that has not been bettered in four-score years, by the Rogers brothers " Much of this work was done by the brothers after tions to the basement crystalline rocks In his annual report for 1839, the Tertiary marl south of the James was described in detail and its Eocene and Miocene ages were noted In the report for 1840 he identified some of the Miocene fossils He also reported the discovery of a "remarkable stratum varying from

DISSECTED APPALACHIAN PLATEAUS IN WESTERN VIRGINIA
THE "BREAKS OF THE SANDY" A TYPICAL GORGE CUT IN THE SANDSTONE PLATEAU

William ceased to be state geologist in 1842, but while he was teaching at the University of Virginia Henry was responsible for many of the principles formulated, William contributed many observations from his remarkable field survey of the Virginias

Rogers classified the Coastal Plain formations according to their periods of deposition and also recognized their rela- 12 to 25 feet in thickness, composed almost entirely of microscopic fossils and lying between the Eocene and Miocene " This was the first recorded discovery of diatomite in the United States

He made studies of New England geology, even before he moved to Boston, in 1853, in order to be able to devote more time to original investigations. As early as 1846 he stated that the site of the

White Mountains had been covered by the sea during Silurian time, a deduction obviously based on the occurrence of fossils On the other hand, he advocated in 1848 that certain glacial boulders could not have been transported by glaciers or icebergs but must have been carried over the high ridge crests by a catastrophic inundation from the Arctic Ocean! The physics of the supposed phenomena was discussed at some length In a discussion before the Boston Society of Natural History in 1860, he stressed principles of stratigraphic paleontology that are currently accepted During this year also he argued, in opposition to Agassiz, that the strata in New York State had accumulated in relatively shallow waters on a slowly subsiding sea floor The discussion continued through two meetings of the society, with the result that Agassiz was at least partly convinced of the correctness of Rogers' view

ROLLING LIMESTONE COUNTRY IN TAZEWELL COUNTY, VIRGINIA
BROAD VALLEYS HAVE BEEN ERODED ON THE LIMESTONE AND SHALE BETWEEN THE HIGH RIDGES CAPPED BY SANDSTONE

Rogers as a Teacher

William Barton Rogers began his professional career as a teacher, by starting with his brother Henry, at twenty-two, a private school near Baltimore He also lectured at the Maryland Institute, where he soon became professor of natural philosophy Upon his father's death, in 1828, he went to the College of William and Mary to occupy the vacant chair of chemistry and natural philosophy After seven years he accepted appointment to the chair of natural philosophy at the University of Virginia which he held until 1853, when he resigned to move to Boston From the beginning of instruction in the Massachusetts Institute of Technology, he taught physics for a few years until administrative duties forced him to relinquish that chair

Rogers was a great teacher whose lectures were eagerly attended by large numbers of students At the centennial of his birth his ability as a teacher was thus described "In power to make difficult things plain, he was unequalled by any other teacher I have ever known His capacity for luminous exposition was really extraordinary . . At his touch complex subjects became simple and

CHARACTERISTIC MOUNTAIN SLOPE IN SOUTHWESTERN VIRGINIA

THE RIDGE IS HELD UP BY FIRM SANDSTONE. THE SLOPES ARE ERODED ON SHALE. THE AREA WAS HEAVILY WOODED WHEN ROGERS DID HIS WORK

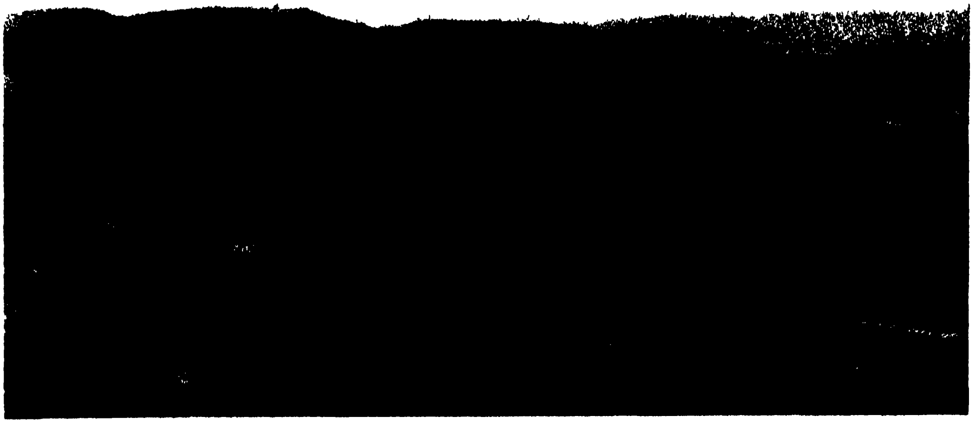
dark things bright." Part of this skill came from his early discovery, as stated in 1829 in a letter to Henry, that "lecturing is in some respects to be considered as an art."

Science Associations

Absorbed as William Barton Rogers was in the art of teaching, in the discovery of new geologic truths in the field and in the practical applications of chemistry and physics, he found the energy and time to contribute positively and permanently in numerous other ways to the advancement of science throughout the nation. With his brothers he was a motivating spirit in the formation of the Association of American Geologists and Naturalists in 1840. The time was ripe for such an organization and the field was clear, for the American Geological Society, formed in 1819 at Yale University, had lasted only a decade. These earnest and farsighted efforts of the Rogers brothers soon bore fruit of undreamed worth. They led on September 24, 1847, to the permanent organization of the American Association for the Advancement of Science, directly from the group organized only seven years earlier. The association in turn was the parent of many leading societies, each devoted to the scientific interests of specialists in particular fields.

Although William B. Rogers has at times been given the additional honor of the first presidency of the association, it appears from the record that he was chairman of the organization meeting, as well as of the first meeting of the association held in Philadelphia the following year. William C. Redfield was chosen the first president. Rogers was president of the association in 1876. Three years later he was elected the third president of the National Academy of Science.

It is probable that the sojourn of Henry Rogers in Europe during 1831–33, which had considerable influence upon William's career as a geologist, initiated or helped mature the idea of a general group of American scientists, for the British Association for the Advance-



PARALLEL RIDGES IN VALLEY AND RIDGE PROVINCE, WEST VIRGINIA

THESE RIDGES WERE FORMED BY THE EROSION OF TILTED SEDIMENTARY ROCKS ON THE FLANKS OF ANTICLINES AND SYNCLINES. THE VALLEYS ARE ON WEAKER ROCKS

ment of Science was organized during that time.

William participated, often with Henry, in the activities of numerous other scientific societies. He had early been made a correspondent of the Philadelphia Academy of Natural Science and a member of the American Philosophical Society. In 1842, he was elected an honorary member of the Boston Society of Natural History. William and Henry were unanimously elected foreign members of the Geological Society of London in 1844.

Massachusetts Institute of Technology

The last, and in some ways the most fruitful, epoch of Rogers' life was concerned with the founding of the Massachusetts Institute of Technology. His zeal for effective public service through the applications of science and his deep interest and broad insight into contemporary problems of education gave rise to a vision that did not long remain far from the realm of the practical.

In a letter in March, 1846, to Henry, who had written from Boston in regard to suggestions for expansion of the Lowell Institute, William at length formulated plans for a Polytechnic School in Boston. He was so imbued with the idea that later in the same day he sent another long letter in which some of his views were further developed. He stated, for instance, that "the true and only practicable object of a Polytechnic School is . . . the teaching, not of the manipulations and minute details of the arts which can be done only in the workshop, but the inculcation of all the scientific principles which form the basis and explanation of them, and along with this a full and methodical review of all their leading processes and operations in connection with physical laws."

In 1862 the Institute was opened for classes, with Rogers as its first president and also as professor of geology and physics. So thorough had been his foresight, so painstaking his plans, so methodical his moves, that it was stated twenty years later that two remarkable

facts about the Institute could only thus be explained the adaptation of the Institute to the public need and the general plan had required almost no modification

Rogers, in spite of ill health that caused temporary retirement, remained the devoted guide of the Institute and one of its energizing spirits As President Walker said in presenting him to the graduating class on May 30, 1882, only a few minutes before he died suddenly while delivering the address "Founder and father is his title perpetual, by a patent indefeasible "

William Barton Rogers, first state geologist of the Virginias and the first teacher of geology in the Commonwealth, blazed the trails and laid the foundation for much of the later geologic research—pure and applied, official and private—in Virginia He should thus be given appropriate rank among those pioneer scientists who built so well with intuitive skill and painstaking labor the broad base of our modern knowledge of Appalachian geology and the natural resources of the Virginias. Rogers also merits high rank as a preceptor and educator as well as an organizer and executive in other fields of science, particularly in applied chemistry and physics His great monument is the Massachusetts Institute of Technology, but he occupies a large niche in the hall of fame associated with the creation and establishment of the American Association for the Advancement of Science

As a result of the achievements of a talented and versatile pioneer Virginia scientist, it is no wonder that Austin Clark has recently said, "In view of his outstanding services to the State it is quite fitting that Virginia's highest mountain should be named for him " It is equally appropriate that this lofty summit should be an enduring reminder of the service of William Barton Rogers to the nation

NATURALISTS IN THE WILDS OF BRITISH COLUMBIA

II. THE ENDING OF WINTER AND THE COMING OF SPRING

JOHN F. and THEODORA C. STANWELL-FLETCHER

GERMANTOWN, PENNSYLVANIA

JANUARY weather was colder on the whole than any other month. For outdoor work we were well clothed, wearing blanket parkas, heavy woolen shirts, warm, thick trousers, woolen socks and moose-skin moccasins. We used two or three pairs of mittens during the course of a day, as the perspiration soaked them, and they became cold and stiff when taken off for a few moments.

A lone white man, a fur trader, lived at certain periods of the year some thirty miles to the north of us on Bear Lake, where he traded with the few local Indians and other tribes from further north. Through an Indian, Chief Bear Lake Charlie, we learned that during this month the trader was expecting a plane to bring him mail and supplies. If we could reach his cabin in time for the plane we might for the first time in many months be able to send out mail and specimens for the museum. We therefore hired Charlie with his dog team to help carry our gear and guide us through the snow-laden and ice-bound valleys to Bear Lake. Bear Lake Charlie was a tall fine man, with graying hair, who always wore a bandana tied around his head and only needed large ear-rings to look the perfect pirate. Charlie had a large family, and when he tried to count his numbers of children he invariably became confused. He had seen much of life and knew well the ways of the wilderness creatures. He was shrewd, could lie with ease and unconcern, and put great store by the large crucifix which he always carried around his neck, suspended by a much-used piece of silk. From the trader he sometimes bought dried fruit, peaches, apricots, prunes and apples, and with these he made home-brew. He did not *sell* it to the other Indians; he merely invited them to join him with a cup or two and when they were settled in his shack he would lean against the door and tell his "guests" how much money the brew had cost, how hard his wife Selma had worked in preparing it, and how hard he had hunted and trapped to get money for buying the necessary ingredients, all in order that he might give his "brothers" a present. Before his guests departed they were shamed into contributing a little as a present also.

The trip to Bear Lake was tiring; deep fresh snow made the going heavy, and late on the first night we were obliged to camp, with a strong bitter wind blowing across the fifteen-mile lake, in Charlie's cabin. We were seven miles from the settlement and very footsore, having broken trail all day for the dogs and toboggan which followed, pushed and guided by Charlie. The wind whistled through the cabin, and the one candle guttered. We sacrificed a precious blanket to hang over the apology of a door. With Charlie and his two sons, aged fifteen and sixteen, who were helping him, we crouched by the tin stove which roared and crackled as the pitchy logs were fed to it. After supper, in the dim

light, Charlie held the family prayers with much gusto and, we fear, entirely for our benefit His dogs outside snarled at each other, and it was a risky business for us to step out into the midst of them The Indians made their beds on one side of the stove and talked together in their own tongue while we lay silent on our side After a time the candle went out, our fresh bed of spruce branches, laid on top of the floor debris of years, was comfortable There were a few snores and mutters—and it was morning

INDIAN AND DOG TEAM ON DRIFTWOOD RIVER MARCH, 1938

At a little after noon we reached the settlement The fur trader, a German, lived a lonely life and gave us a hearty welcome His cabin, delightfully clean after the night in old Charlie's, had two small rooms, one his living-room, the other the store where he carried on his trades We slept on the store floor at night, listened to up-to-date news on his radio, and worked over our mail and museum specimens in the daytime We spent a week there and became a little acquainted with the Indians of the village On the eve of our departure a boy came from the village, which was a quarter of a mile from the trader's store, and presented us with a soiled leaf from a notebook On it was written in pencil "Dance TONITE at 7–30 P M By S A Wright " This was an invitation to a gathering in our honor No white lady as far as we could find out had visited these people before, and they wished to show their appreciation Armed with a few boxes of chocolate bars, we arrived in the middle of a fox-trot at the freshly scrubbed shack We learned later that one of the Indians who had been "outside" had picked up this new dance and introduced it on his return Gay young bucks, dressed in shirts with collars and ties, danced in their moose-skin moccasins with flamboyant squaws of various ages One fine-looking chap had a light green scarf tied around his waist with a straight hair comb of the same shade stuck in his black hair When the dance was well under way old Charlie came in with Selma, who carried a tin can which

TRACK MADE BY TWO WOLVES BESIDE SNOW-SHOE TRACK OF MR FLETCHER

she placed on the floor as Charlie's private spittoon

The orchestra was made up of a violin, a guitar and an accordion We applauded, listened to a lengthy but courteous welcoming speech given by the master of ceremonies, and replied by a speech ourselves of equal length An hour later, at our request, we were given an exhibition of an old Indian tribal dance by two modern-looking couples But it was obvious that the white man's fox-trots were considered as the proper thing and more to their taste

It was during February that the wolves came Their tracks were everywhere, and often they came within a hundred yards or so of our cabin They were huge creatures, for a single footprint often measured six inches across, and skins, which we later saw at the Hudson's Bay Post, were seven feet from nose tip to tail tip. Occasionally we heard them in the distance. The sun was swinging higher each day and with the long hours of sunshine and preponderance of clear days, the snow melted and packed during the daytime to freeze at night when the thermometer still went down to twenty or thirty degrees below zero Fahrenheit This made traveling on top of the hard crust pleasant for us, and the larger, heavier animals, like wolves, coyotes and moose, appeared again from other parts of the country where traveling conditions had been better during the early winter months Whenever there was a fresh powdering of snow, the forests, swamps and meadows were laced with tracks of mice, shrews, squirrels, weasels, hares, mink and marten, wolves and coyotes The moose stuck to swamps and the river banks, where they fed largely on young willow shoots

One clear night at the full of the moon, after a fresh fall of snow, with the mercury at twenty-four degrees below zero Fahrenheit, we took a snow-shoe tramp at midnight through a fairyland of snow-covered trees and shadows, to a hill from the top of which there was a particularly fine view up and down the whole Driftwood Valley It was light as day, and the stillness of the forest, mountains and lakes below us glittering in the moonlight

VIEW OF DRIFTWOOD VALLEY FEBRUARY, 1938

was thrilling as only a northern night can make it Nothing either of us had ever seen in tropical places of the world or elsewhere could compare in sheer beauty with the nights of a northern winter As we stood as silent as the wilderness around us, a lone wolf somewhere below us began to sing Its musical voice, low and modulated, rose gradually to a high note and then as gradually died away, only to rise again and again It was so full of sadness and yearning as it called for its mate that we marvelled at the soul and intelligence which could make so stirring a song When it finally ceased we slid down the steep hillside sitting on the crossed heels of our snow-shoes and using them like toboggans Clouds of sparkling snow flew up behind us, and it was getting colder every minute.

After that night we heard the wolves on and off through March and part of April Sometimes they sang alone or in choruses of perhaps ten or fifteen judging by the tracks found the next day Often we started from our seats at the evening meal to hear wolves just across the lake from the cabin These earlier choruses usually began with one or two voices, which were joined by the others, one by one taking up the song in perfect harmony It was sheer music of the most thrilling heart-stirring kind Later on in the spring, in April, when the mating season seemed to be over, we heard the hunting song This was fierce and blood-curdling and eerie, it differed markedly from the love call Our feelings of warm affection toward the wolves became tinged with respect and a slight chill

During all this time we actually saw no wolves The Indians who had lived in this country all their lives told us that they saw them very seldom in the forested parts, while on the big lakes and open plateau country they were a not uncommon sight We knew, however, that the wolves saw us, for we found their great tracks where they had stepped aside from the trail while we went by. Often they followed us, no doubt from sheer curiosity On one occasion when we were returning from a several days' journey, a broken snow-shoe harness caused one of us to drop behind the other in order to fix it As we were about four miles from

LAKE TETANA MARCH, 1938

FISHING FOR TROUT IN DUG OUT CANOE ALONG THE DRIFTWOOD RIVER.

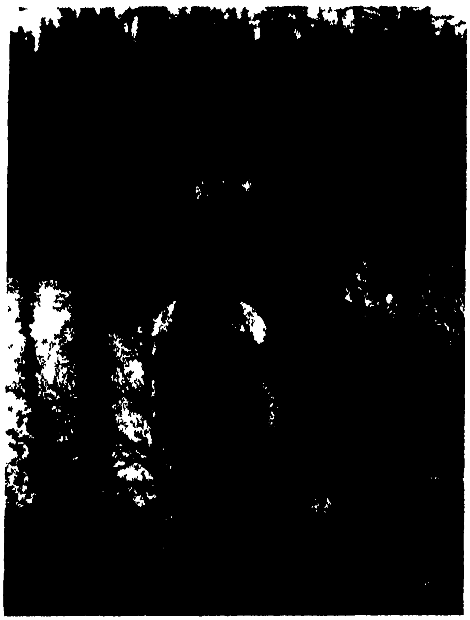
the cabin and night was advancing rapidly, the other went on ahead to break trail and get the fire going in the stove The one behind was conscious of being followed to within a mile or so of the cabin, although she could see no visible signs of it and judged only by that intuitive sense which one soon develops after a few months in a country where there are no man-made sounds or signs of any sort, other than one's own The next day two Indians, who had followed along part of our trail, asked us if we had seen the six wolves that had obviously followed us for some miles These tracks were made at exactly the same time as the last snowshoe trail, they claimed The Indians were usually accurate judges of the age of animal tracks and could often tell the hour at which a track had been made, just as they could tell the time of day within half an hour, without a timepiece

In all that country we could learn of no first-hand cases of any human person having been attacked by wolves, although wolves were sometimes reported in companies of fifteen or even thirty individuals. That these northern timber wolves possessed a remarkably high order of intelligence was agreed upon by all authorities The Indians around us had many superstitions regarding wolves; a rifle that killed a wolf would soon kill a human, or a person born at a certain time must never hunt or kill a wolf, because if he did, his nearest female relative was certain to become insane

According to the game authorities the wolves in some districts were increasing to such an extent that they were becoming a serious menace to the moose population On one of Sapolio's visits, he reported to us that he had just seen five moose that had been killed by wolves, all within a mile of each other They had been hamstrung and only partly eaten Later, however, the wolves returned and finished the carcasses Wherever we found animals fed upon by wolves, there was no sign of waste, as there so often is when they are killed by the Indians or white man

ALPINE MEADOWS, NORTHEAST OF BEAR LAKE, B C JULY, 1939

In the autumn and spring, during periods of marked seasonal change, we



MRS FLETCHER AND CATCH
DOLLY VARDEN TROUT WEIGHING 6½ AND 8 POUNDS

saw displays of the aurora borealis These were much more vivid in the spring, when they appeared on and off for about one month, chiefly in March They began around 10 00 P M. nearly always over the heavy spruce forest to the east They were yellow-green zigzags which gradually became rose and lavender streamers reaching up to the zenith To one unaccustomed to the awesome powers of the north the aurora as we saw it in March over our Driftwood Valley was one of the great marvels of life Occasionally it took on an unusual form One night at 1 00 A.M we woke to see huge clouds of crimson rolling down the valley The open patch of water on the lake and all the snow around reflected the deep red And this in spite of a moon which was making the white world bright with light Our first thought was of some big fire, till we realized that this was impossible in a world buried deep in snow with the nearest town of any size hundreds of miles away

By the end of February our food supply, obtained in bulk the previous September, was in need of replenishing, and so early in March we went down to Takla Landing, sixty miles away, to do our shopping for the spring and summer One of Bear Lake Charlie's sons followed behind us with four dogs and a toboggan, which carried our impedimenta and more specimens for the museum We followed the tortuous Driftwood River most of the way, adding to our mileage, but making better time than would have been possible in the soft deep snow of the woods By noon the sun's rays melted the crust which formed on the snow during the night Our snow-shoes were wet and terribly heavy and the harness rubbed and blistered our toes badly in their wet socks and moccasins The glare on the melting crust and the long hours of sunshine were tiring, and dark glasses essential When we left the river to go through the forests, we traveled much more slowly The trees were thick, the snow bad, and often at steep banks the toboggan crashed and slid downhill with the dogs tangled around trees and themselves At noon on the second day we reached the north end of Takla Lake The following morning we started off down the lake, our snow-shoes tied on the toboggan, for the ice on the lake was level and almost free from snow At 11 00 A M we stopped near the shore to make tea, then on again, our eyes, even with the dark glasses, smarting and bloodshot from the intense glare on the glittering lake After five and a half hours of travel we reached the settlement, having come twenty-five miles that day and approximately eighty miles altogether from our cabin

The few white people at Takla Landing were most kind and hospitable and curious to see how we had survived the winter But we were anxious to get back to the solitude of our cabin and Lake Tetana before two days had passed, for by that time we were more wedded to our wilderness life than ever.

During our year and a half in the Driftwood Valley region we had six

white visitors One was an old gold prospector, with one hand, who stopped at our cabin on his way "out" in the spring His Indian guide had deserted him when he had come half way to Takla, and his snow-shoes were badly broken He had with him a beautiful Alsatian dog and her two pups, aged four months They had already traveled on foot over one hundred and ninety miles After two nights' sleep on our cabin floor and a good rest we saw him well on his way, with mended snow-shoes and minus one of the pups, "Rex," which he had given to us This little fellow was soon to become our devoted companion and guard and was much admired—and respected—by the Indians

In April, although the snow still lay deep everywhere, the winter silence over the land gave way to the rustle of wings and the noisy courting of birds Ducks, geese and swans began to go northward and occasionally rested for a while on the partly open water of our small lake The night of April 10th was warm and still with a misty rain and the moon showing faintly through the clouds At 11.00 P M, as we were just going off to sleep, we were roused by a deep melodious chorus of trumpets all around and over the cabin We fell out of our beds and leaned from a window, to see four great white birds They were low down, their bodies gleaming in the soft light as they circled over us They were trumpeter swans (*Cygnus buccinator*), for no other species could make that music Each voice was individual, the whole made an exquisite harmony The four swans did not land, but flew off, and at the same time we heard more soft trumpets overhead and saw the tail-end of a V comprising twelve swans Long after they disappeared into the northwest, we heard their fairy-like voices as they hailed each other along On five other occasions, during April, we heard and saw more flocks of these majestic birds, all going northwest, we counted one hundred and ninety individuals Some

WITH DOLLY VARDEN TROUT
MR FLETCHER HOLDING 8½ AND 9½ POUND FISH

passed us during the night, their musical toot-toots announcing their coming far ahead. One morning at sunrise, we stood in an open snow-covered meadow, as a flock of forty-three trumpeters passed slowly over us with the sun's rays on their wings and their lovely voices echoing up and down the valley in the still air

After most of the trumpeters had gone north, the whistling swans (*Cygnus columbianus*) came through Their notes were harsh by comparison, with something of a wheeze in them, and so distinct from the trumpeters that we felt there was little chance of confusing the two species We counted two hundred ninety-three whistling swans. On November 1, 1938, on Bear Lake we saw fourteen swans, which were mostly immature, and permitted us to paddle within fifty yards of them It was snowing hard at the time, and we were unable to photograph them We saw a few other companies going south during the fall, but they were rather quiet and we could not distinguish the species. From In-

dians and others we learned that one of the possible reasons for the scarcity of trumpeter swans is the fact that at their winter quarters they are often caught by sudden frosts while sleeping, and are frozen into the thin ice, thus becoming easy prey for foxes and coyotes.

We had a fairly large variety of wild ducks on Lake Tetana throughout April and May. There were common mergansers (*Mergus merganser*), common and Barrow's golden-eyes (*Glaucionetta clangula* and *Glaucionetta islandica*), mallards (*Anas platyrhynchos*), green-winged teals (*Nettion carolinensis*), pintails (*Dafila acuta*), baldpates (*Mareca americana*), buffle-heads (*Charitonetta albeola*), shovellers (*Spatula clypeata*), ruddies (*Erismatura jamaicensis*), lesser scaups (*Nyroca affinis*) and one old squaw (*Clangula hiemalis*). The mergansers, pintails and teals were going through their mating activities in May in the rapidly enlarging open stretch of water below the cabin. The Barrow's golden-eyes were perhaps the most gorgeous of the ducks to look at. The males tossed their royal purple heads high above the velvet markings of their black and white bodies. Both sexes waved their heads from side to side, strutted and primped, and chased each other furiously, long into the night, with a clatter and whistle of wings. Two pairs were with us all spring and seemed unable to decide who belonged to whom. But they must have reached some agreement finally, for two females with their young were around our lake throughout the summer. On June 21st, one female with five youngsters, three or four inches long, was seen. We watched them on and off until early August. The male was very little in evidence, the mother apparently doing all the training and guarding of the young. We often saw her teaching them to follow close behind her in single file, or to float down the swift current of the river near the lake outlet without mishap. At the end of the summer two of the young had disappeared, but the others apparently grew up successfully.

LAKE TETANA APRIL, 1938

As the lake became more and more

open, large companies of ducks came in at night; sometimes we counted up to one hundred or more Many of them would shoot down over our cabin just at dusk, at terrific speed, with a whirring of wings and a splash as they landed below us At times they appeared to miss the cabin roof by a few feet only

The spring days and nights were as full of sounds and active life as the long winter ones had been devoid of sound and live things The noise of running water, winds amounting to gales, and singing birds, filled the days Swallows, tree (*Iridoprocne bicolor*) and violet-green (*Tachycineta thalassina lepida*), exquisite in color, darted here and there over the lake Ruby (*Regulus calendula calendula*) and golden-crowned kinglets (*Regulus satrapa olivaceus*) were everywhere Rufus humming-birds (*Selasphorus rufus*), red-breasted sapsuckers (*Spyrapicus varius ruber*), eastern purple finches (*Carpodacus purpureus purpureus*), rusty and Brewer's blackbirds (*Euphagus carolinus* and *Euphagus cyanocephalus*), and various kinds of warblers pileolated (*Wilsonia pusilla pileolata*), MacGillivray's (*Oporornis tolmiei*), redstarts (*Setophaga ruticilla*), magnolias (*Dendroica magnolia*), black-polls (*Dendroica striata*), Audubon's (*Dendroica auduboni*), etc, made the trees and shrubs around us gay with color Olive-backed (*Hylocichla ustulata swainsoni*) thrushes around the lake shores and grey-cheeked (*Hylocichla minima aliciae*) along the river sang all the long evenings through, until darkness came

One May morning when we got up, we were surprised to find a strange Indian sitting on our wood-pile behind the cabin With him was a dejected-looking dog He was on his way from north of Bear Lake to Takla Landing, and had tried to come down the Driftwood River, which was in flood at that season, on a raft The raft was wrecked

TOADS DURING MATING SEASON
MALE ON TOP OF FEMALE MAY, 1938

NEST OF MacGILLIVRAY'S WARBLER

at a log jam the night before, about a mile from our cabin, and he and the dog, which had been tied to the raft, had very nearly drowned. All his supplies were lost with the raft, food, bedding, gun and axe He had managed to save three matches by holding one hand above the surface of the water To be caught in that country without gun, axe and a sufficient supply of matches is a serious matter, for they are the sources of the essentials of life · food, shelter and warmth The tale of this chap's little adventure

GRAY HEADED CHIPMUNK FEEDING ON PUSSY WILLOWS
ON NUMEROUS OCCASIONS THIS SPECIES WAS SEEN TO FEED REGULARLY ON THE WILLOWS AS SHOWN HERE, DEVOURING AT LEAST 80 PER CENT

came out by degrees in halting English, in the matter-of-fact way typical of the country It was just one of those unnecessary things that was apt to happen, and there was no use making a fuss about it He was lucky, he said, to have been so near to us and to have found our cabin, that was all We fed him a breakfast of beans, bannock and coffee, for he had not eaten since early on the previous day, and his dog had a lump of meat that made his eyes bulge We gave the man biscuits, meat, tea, sugar and matches to take with him He made himself a kettle out of a tin can and wire, said, "Well—thanks" and departed, a damp, silent, philosophical figure

From mid-April to the middle of June all the rivers and streams in the country were flooded Innocent little creeks became roaring torrents which were difficult or impossible to cross Traveling conditions were very bad, and we were as effectively cut off from the outside world as we had been during the first months of winter, when the snow was too deep and soft to allow more than a few miles a day of travel Our lake level rose fifteen feet as the flooded river backed into it by way of the short narrow channel out of which the lake normally flowed into the river, and the crystal-clear green and blue depths turned muddy Even the springs near the cabin were barely strong enough to push back the oncoming tide of murky water By mid-June all snow was gone from the open country, though there were snow banks in the shaded parts of the woods On the mountains it was still four to five feet deep

In May we replenished our larder with trout from the river Our casting rods did yeomon service, and many a rainbow (*Salmo gairdnerii kamloops*) and Dolly Varden (*Salvelinus malma*) gave us a double thrill—first in the catching, second in the eating The snags and drifting logs of the swollen river made us

lose many fish and spoons The Dolly Varden were the most common, and we often caught them weighing eight to ten pounds. When we cleaned the fish we found eggs or milt in most of them, indicating that this was then spawning season in our part of the world Later, we obtained lake trout (*Cristivomer namaycush*) from Bear Lake, but these were sluggish and by no means as fine eating as the trout from the Driftwood River

When the floods subsided the lake became clear once more The flowers bloomed everywhere, and the bears hunted for grubs in dead and rotten logs Our lake seemed suddenly to be alive with swimming toads (*Bufo boreas boreas*) and warm evenings echoed with their shrill and not unmusical trills When we went out in our dug-out canoe, recently purchased from Bear Lake Charlie, we picked up toads, single and in pairs, which were swimming as much as two hundred yards from the shores The females, larger and much more vivid in color, were a bright reddish brown or green with cream markings The males rode on the backs of the females, their thumbs clasped beneath the latter's front legs in what was practically a death grip, in which position they would remain until the eggs were extruded and fertilized by the male sperms We collected five or six mating pairs, as well as some single individuals, and put them in jars and pots inside the cabin Even when caught and put in new quarters the males did not release their grip of the females. After four days one female extruded her eggs in a long, tangled string of jelly We hunted extensively, but could find no eggs in our lake, nor did we ever discover any tadpoles during the entire summer, though we saw millions in some of the much warmer lakes and ponds near us What happened to the eggs of the mating toads of our lake, if they left their eggs there at all, is a mystery still to be solved During the summer and two autumns which we spent in this Driftwood Valley region, we found the adults of this common toad everywhere on land On the other hand, we found only two species of frogs (*Rana pretiosa* and *Rana cantabrigensis*), and these were rare We saw two of the former and three of the latter In all that time we had also seen only one salamander (*Ambystoma macrodactylum*), and this had been found near the lake shore by one of the Indians who helped us to build the cabin It was five inches long, black on the top with a marbling of greenish-gold markings, mottled with gray on the belly

At the time when we collected the mating toads, we showed the pairs to two of Charlie's sons, explaining their methods of "making children," as the Indians termed it To our surprise the boys jumped away and hurried out of the cabin We later learned that some of their most serious superstitions were connected with "frogs" It was quite taboo for them to touch or get near "frogs" Such an action meant death or illness and all sorts of horrible things. There were superstitions regarding the salamander also, which "carried gold on its back," and to touch one might mean that a man would lose all his worldly possessions. The Indians usually told us of these beliefs with slight grins, but at the same time they did not want to take any chances—"in case"

"THE APOTHEOSIS OF SCIENCE"[1]

By ROBERT LOVELL BLACK

EMMERICH MANUAL TRAINING SCHOOL, INDIANAPOLIS, IND

"THE Apotheosis of Science," a mural painting of heroic conception, was executed by Elmer E Taflinger, of Indianapolis, Indiana For five years Robert Lovell Black and Mr Taflinger collaborated, as scientist and artist, in producing an artistic, historical and educational canvas in honor of science and the great scientists who have created it The completed painting is now installed for the inspiration of students in Mr Black's classroom at Emmerich Manual Training High School, Indianapolis

The painting is twenty-one feet long and five and one half feet high, in oil, on canvas, and is divided into three panels The center panel (Fig 1) portrays representative plants and animals of each of the main classes of each phylum of the animal kingdom and plant kingdom The center portion of the center panel contains four Greek scientists of the ancient world, two on either side, each symbolical of one of the four ancient elements, fire, water, earth and air They are placed in defensive positions, guarding life as

[1] "A History of Science in Mural Painting Fifty-two Scientists and a Classification of Living Things" Robert Lovell Black, Emmerich Manual Training High School, Indianapolis, Indiana

FIG 1. CENTER PANEL

FIG 2 LEFT PANEL

shown in the center In the side panels are shown forty-eight of the great scientists of all ages, painted in naturalistic positions, and arranged according to their field of work rather than the period in which they lived The men in the left panel (Fig 2) were interested in living things, mainly in the fields of botany, zoology, physiology, anatomy, genetics and medicine, while those on the right panel (Fig 3) dealt mainly with pure science as represented by mathematics, physics, astronomy and chemistry Each scientist has reached a summit in some realm of scientific achievement and is portrayed as standing on a mountain top with valleys and peaks in the background Each one holds in his hand a symbol of his accomplishment

The foreground of the picture shows the remains of great periods of civilization, which have risen and fallen while the search for truth by the scientists has continued steadily forward Such objects as the helmet of Menelaus, Alexander's sword, a standard bearing the S P Q R. of the Romans, the torso of Hercules on an Ionic column, a Roman millstone and arch, an astrolabe, a globe, the unfinished statue of the slave by Michelangelo on top of a Renaissance column, manuscripts, a hat of Napoleon, the skull of his horse with a sword thrust through it, skulls of soldiers, remains of architecture, wrecked trees and timbers, twisted steel beams, a broken air-plane propeller, a helmet of a soldier in the World War, and a standard of the A E F symbolize

the ancient world, the Middle Ages, the Renaissance, the Napoleonic period and the World War

One of the most interesting things about the production of the painting was the way in which the fifty-two scientists were chosen A list of twenty great scientists of all periods was submitted to more than a hundred scientists, editors, university professors and prominent people in various walks of life They voted on the names sent to them, and in many cases sent back additional names which they thought should be included These answers were analyzed and tabulated. As a result, two names, Pliny and Abelard, were eliminated from the original list, and thirty-four new names were added. Among the scientists consulted were Robert A Millikan, Arthur H Compton, Karl T. Compton, Thomas Hunt Morgan, William Hornaday, William Beebe, Morris Fishbein, Otis W. Caldwell and Tenney L Davis

The names of the scientists who were selected are in order from left to right as they appear in the painting In the left panel Lyell, Humboldt, Audubon, Lamarck, Linnaeus, Helmholtz, Cuvier, Roentgen, Vesalius, Harvey, Leeuwenhoek, Langley, Schwann, Bernard, T H Morgan, Schultz, Darwin, Mendel, Lister, Pasteur, Galen and Alhazen In the middle panel Aristotle, Hippocrates, Archimedes and Euclid In the right panel · Roger Bacon, Copernicus, Watt, Galileo, Newton, Huygens, Laplace, Descartes, Einstein, Leibnitz, Planck, Mendelejeff, Franklin, Lavoisier, Galton, Faraday, Rutherford, Arthur Compton, J J

FIG 3. RIGHT PANEL

Thomson, Millikan, Maxwell, Hertz and Crooks

The center panel, which shows the classification of plants and animals, presented a complex problem which was worked out on a plan of concentric circles The composition of the painting, the colors and the lighting all work together to simplify and unify the subject-matter In three small concentric circles in the lower portion of the center panel appear representatives of each of the classes of the nine major phyla of the invertebrates In the middle circle appear Protozoa, Porifera and Coelenterata, a cell, complete in detail, and various stages of oogenesis, spermatogenesis and embryology In the circle on the left appear Platyhelminthes, Nemathelminthes, and Echinodermata In the circle on the right appear Annelida, Mollusca and Arthropoda

In the large circle in the center of the panel are representatives of each of the sub-phyla of the phylum Chordata The representatives of each of the six classes of sub-phylum Vertebrata, Elasmobranchii, Pisces, Amphibia, Reptilia, Aves and Mammalia occupy most of the area of this large circle In the center of this circle is a semi-transparent three-headed, four-armed, single-trunked, four-legged symbolical figure which represents the three primary races of the family Hominidae The head in the middle represents the Caucasian race It is a copy of the self-portrait of Leonardo da Vinci, as typifying the highest "all-round" man, painter, sculptor, architect, musician, engineer and scientist The heads to the left and right behind da Vinci represent the Negroid and Mongoloid races, respectively The design of this part of the painting was based on da Vinci's study of Vetruvius He found that when a man stands with feet together and arms spread horizontally, the figure forms a square, and that when a man stands with feet spread apart and the arms raised to a forty-five degree angle (or "spread-eagle"), the figure forms a circle Ingeniously worked into the background of the large circle are representatives of the classes of the four major phyla of plants, Thallophyta, Bryophyta, Pteridophyta and Spermatophyta

COOPERATION IN ASTRONOMY

By Dr. OTTO STRUVE

DIRECTOR OF THE YERKES AND McDONALD OBSERVATORIES

THE McDonald Observatory of the University of Texas was officially dedicated on May 5, 1939 It is equipped with a reflecting telescope 82 inches in aperture, and it is, by virtue of this fine equipment, one of the important centers of astronomical research of the world The observatory is operated jointly by the University of Chicago, which supplies the staff from its own Yerkes Observatory at Williams Bay, Wisconsin, and provides the larger part of the operating funds, and by the University of Texas, which built the entire plant from the bequest of W J McDonald, of Paris, Texas, and which, in addition, pays for part of the maintenance

The plan of collaboration, entered into by the two universities, has been very successful Without this plan, the 82-inch telescope would not have come into existence, the Yerkes Observatory would not have been able to increase its scientific output and would not have attracted to its staff new astronomers of high international standing, the University of Texas would not now own one of the world's most powerful telescopes, and would not have become the sponsor of some of the most intensive research in astronomy

Although the new telescope has been in operation for only nine months, some interesting scientific results have been secured with it Dr Polydore Swings, visiting professor at the University of Chicago, has already announced the discovery of a large number of "forbidden" radiations, hitherto unknown, in stellar spectra photographed by him last month at the McDonald Observatory Forbidden radiations can not be observed in the physical laboratory, and without astronomical observation they would have remained unknown Although these radiations are "forbidden" on the earth, they occur in the vast spaces of the universe where low density of gas, almost limitless space and permanent semi-darkness are conditions required for their origin It is unnecessary to dwell upon the importance of this knowledge the physicist knows that to understand the properties of matter he must understand the radiations which matter is capable of producing He has studied in the laboratory the "permitted" radiations, but his data would be unintelligible without a knowledge of the "forbidden" radiations

The most important discovery made by Dr Swings is that of a forbidden line of the element Fe X (iron ten) Under normal conditions the atom of iron possesses twenty-six electrons When energy in the form of light or in the form of a shock—perhaps a collision with another particle—is applied to an iron atom, it may lose its outermost electron, after which it would be designated as Fe II If more energy is applied, it may lose two electrons and it then becomes Fe III, and so on The energies required to produce these changes are great In the atmosphere of the sun we observe Fe I, with a little admixture of Fe II, and with no Fe III at all Little imagination is required to realize the tremendous amount of heat and light in the surface layers of the sun And yet, they are barely sufficient to create and maintain Fe II in a gas whose density is ten thousand times less than that of the air we breathe In some of the hottest stars Fe III was found last year by Dr Swings,

and was confirmed through a study of photographs made with the 82-inch reflector

Astrophysicists have established a scale of energies to measure the forces which must be applied to an atom to break off its various electrons The unit of this scale is the electron-volt that is set, by agreement, equal to the energy which is acquired by an electron when it passes through a potential difference of one volt To knock off the first electron of an iron atom requires 8 electron-volts, to produce Fe III requires 16 electron-volts But to produce Fe X requires about 200 electron-volts—an energy which has not hitherto been contemplated in astrophysical studies! This is in itself remarkable, but to the physicist a still more significant point is the fact that the forbidden line is produced by a transition between the sub-levels of the same multiple state No other forbidden line of this type had ever before been observed, although Dr Theodore Dunham at Mount Wilson had inferred, theoretically, that such transitions must occur in the gases which fill the spaces between the stars

Dr Gerard P Kuiper, of the Yerkes Observatory staff, is now engaged in the discovery and study of some very strange stars which we designate "white dwarfs" This name gives but an imperfect idea of the remarkable properties of these stars They are called "dwarfs" because they are small—some are smaller even than the earth And they are "white" because their temperatures are high—of the order of 10,000° Centigrade at their surfaces What the name does not indicate, and what is really of most importance, is the fact that in mass they are not dwarfs, for their masses are of the order of that of the sun If you could squeeze a mass comparable to that of the sun into a volume smaller than that of the earth, you would have a density so enormous that it defies the imagination Kuiper has computed for one of his stars a mass of one thousand tons per cubic inch. Such matter is not ordinary matter at all—we have nothing like it on the earth or on the sun, and we call it "degenerate matter" The problem is to find, by means of astronomical observations, the properties of this "degenerate matter" We already know that it follows quite different laws of physics than does ordinary terrestrial matter, and we hope that we shall ultimately discover how it reacts to changes in pressure and temperature

For years astronomers have been interested in the problem of the chemical composition of the stars The question is an intricate one The tremendous energies radiated by the stars into space in the form of heat and light are almost certainly produced by the slow conversion of certain kinds of atoms into other forms We have heard much in recent months of the so-called carbon cycle, of the proton-proton mechanism, and of other processes which may account for the heat and light of the stars These processes gradually use up the available hydrogen and thereby reduce its abundance There is ample indirect evidence that the hydrogen contents of the stellar interiors are not all the same. The only way we can directly observe the composition of a star is to study its spectrum

It might appear to be an easy task to determine the amount of each chemical element in the outer layers of a star from its spectrum In reality, the problem is very difficult, and little trustworthy information has thus far been obtained In a few cases we suspect that hydrogen is less abundant than it is in normal stellar atmospheres, but the evidence is limited to some rather unusual objects whose spectra are quite difficult to interpret At the McDonald Observatory, Dr Jesse Greenstein observed the star υ Sagittarii, which had been previously observed at the Yerkes Observatory and elsewhere, but only in the blue and violet

regions of the spectrum. The new work, carried out in ultra-violet light, was facilitated by the high reflecting power of aluminum with which the 82-inch mirror is coated and by the excellent transparency for ultra-violet light of the quartz prisms of the spectrograph

The work on υ Sagittarii shows that it is a star whose atmosphere contains an abnormally small amount of hydrogen. From the point of view of chemical composition, it is by far the most interesting object in the sky, and it is very remarkable in another respect In normal stars of its class, which have surface temperatures of about 10,000° Centigrade, the atoms of hydrogen and the free electrons produce a certain amount of haziness in their atmospheres which prevents us from seeing into their deeper layers In υ Sagittarii, however, the hydrogen content is low, the metals contribute a relatively greater share to the free electrons, and the opacity, or haziness, of the atmosphere is, therefore, not the same as in a normal star The theory of the formation of stellar spectra depends entirely upon this opacity There has previously been little opportunity to secure observational evidence in support of this conclusion, but υ Sagittarii provides the ideal material for testing the theory.

Since its installation on Mount Locke the 82-inch reflector has been in constant demand and has provided a continuous flow of scientific material Dr A. Unsold has collaborated with me in studying the ultra-violet spectra of B and A stars, Unsold has also determined the curve of growth of Arcturus; Roach has cleared up some of the mysteries of P Cygni, and Page has observed the spectra of planetary nebulae A program of radial velocities of faint B stars is being carried out by Popper and Seyfert.

All this work owes its inception to the cooperative arrangement between the University of Texas and the University of Chicago Astronomers have always been eager to cooperate. They have carried out large international projects, such as the complete mapping of the sky with photographic telescopes distributed all over the world, and the determination of accurate star positions with meridian circles in a dozen or more observatories They have organized international bureaus for the distribution of astronomical news, such as discoveries of comets and novae But universities have rarely been willing to pool their resources for the maintenance of a large observatory The Chicago-Texas arrangement, and the somewhat similar arrangement between Ohio State University and Ohio Wesleyan University in maintaining the Perkins Observatory, are a new demonstration that satisfactory results can be obtained by collaboration

The greater number of existing astronomical observatories in the United States were built and equipped from funds donated by private persons Most of these institutions were opened when instrumental equipment was not as highly developed and not nearly as costly as it is to-day When the plans for the Yerkes Observatory were first considered in 1892, the secretary of the university recalled that, not many years before, the old University of Chicago had owned the largest astronomical instrument then in existence—a telescope (now at the Dearborn Observatory) having an objective 18½ inches in diameter Since that time telescopes had been made with objectives having diameters of 20, 23, 24, 25, 26, 27, 28, 30 and 36 inches The Yerkes 40-inch refractor was completed in 1897, but a few years later the 60-inch reflector at Mount Wilson and, finally, the 100-inch Hooker reflector at Mount Wilson became, in turn, the world's largest telescopes.

Large apertures mean great light-gathering power. Not all astronomical investigations require great light-gathering power, but many do. An astronomer

who has at his disposal a 15-inch telescope can carry on certain types of research, but he can not participate in some of the most interesting and fruitful investigations now in progress at the larger observatories. Doubtless many able astronomers have experienced a deep feeling of disappointment when limitations of instrumental facilities have prevented them from carrying on the type of research which they considered most useful and valuable. Yet, restrictions of university budgets and the rapid decrease in the frequency of large private donations leave little hope for the improvement of small and inadequately equipped observatories. During the period of 31 years between the construction of the Dearborn 18½-inch telescope and the Yerkes 40-inch telescope, the priority in aperture passed through ten different institutions. Since the completion of the Mount Wilson 60-inch reflector in 1908 it has remained with the same institution.

There can be no doubt that the growing disparity between the facilities for research available at various observatories raises a serious problem for the future development of astronomy. Fifty years ago practical work in astronomy was rather uniformly distributed among a large number of observatories in Europe and America. As time goes on we see a growing tendency to reduce observational activities at the smaller institutions. The existing equipment is usually insufficient and funds are not available for a complete modernization. Moreover, at some of the eastern and middle-western institutions the climate is not good enough for the efficient utilization of a large telescope. The organization and maintenance of a separate observing station in the southern hemisphere, or even in our own Southwest, is beyond the resources of the average university.

Hence, there has been a general tendency to substitute theoretical studies for observational work. Fortunately, in the United States this process has only started. But in Europe we have seen the gradual decline of observational work and the rise of theoretical institutions. The Kapteyn Institute at Groningen, Holland, the theoretical astrophysical institute at Oslo, Norway, the substitution of a theoretical department for what was once the University Observatory at Kiel, Germany, and, above all, the rise of theoretical astrophysics in England during and after the World War are striking examples.

I believe we must guard against this tendency in the United States. After all, the success of theoretical study depends essentially upon the supply of observational results. These now come almost entirely from a few large American observatories. There is, of course, no danger that Mount Wilson, Lick, Harvard and a few other observatories will not continue their observational activities on their present scale. But is it wise to restrict all observational work to a small number of institutions? Is this not likely to produce a cleavage between theoretical astronomers and observers which will result in much confusion and unsatisfactory progress? Is it not also rather disquieting when we contemplate the number of young astronomers who are being trained for future careers at institutions which are unable to carry on modern observational activities? The present trend toward pure theory is not a natural process, but is one which is forced upon astronomy by restricting circumstances.

I fear that unless something is done toward equalizing the research opportunities of all astronomers there will be a gradual deterioration of many observatories which, in the past, have been able to carry on investigations of a quality comparable to that of the largest institutions. Half-measures are expensive

and are not satisfactory. The difficulty which is normally experienced in a present-day observatory of limited means is not a lack of problems which can be attacked and solved with the available equipment Even the most modest observatory can do *some* useful work. Important contributions to science are often made with small equipment. Ross's Milky Way Atlas was made with a 5-inch lens, Merrill's catalogue of emission stars is based largely upon observations obtained with a 10-inch telescope and the Harvard spectroscopic surveys were made with instruments of relatively small aperture But it is significant that all these investigations were made at large observatories, in spite of the fact that such instrumental equipment could have been easily available at a small observatory

The difficulty is, of course, that the small observatory is compelled to search for something that it is able to do, instead of doing what is scientifically important and interesting An observatory which has only a 12-inch visual refractor can do useful work on double stars and variable stars, but the limitation is quite likely to destroy initiative even in this restricted field When a scientist is unable to do what he considers necessary and is constrained to do what his telescope allows him to undertake, he not only loses interest but often loses his contact with modern developments, his department deteriorates, his students suffer from the narrowness of the institution's interests In the meantime the observatory continues to draw heavily from the university's general budget. With normal deterioration the instruments and buildings are more than likely to require increased appropriations as time goes on, but the scientific output becomes, if not less in volume, certainly less in value

Fortunately, it is not necessary for this process to continue A powerful modern telescope provides a wealth of material Some of it can be utilized immediately by the observer. But more often than not the photographic plates contain valuable material which is not immediately used and which is often not even appraised by the observer. It is certain that by cooperation we can do our telescopic work more efficiently than we have done it in the past, and supply a greater number of astronomers with material

If several observatories would pool their resources they would be able to construct a series of instruments designed for special purposes. The whole equipment would constitute a first-class observatory, although separately each instrument might not be of great value For example, the McDonald Observatory has a large reflector which is suitable for work with slit spectrographs But it has no powerful camera for objective-prism work and may never be able to purchase such an instrument It would be advantageous for us to collaborate with some other institution which may be contemplating the construction of a new instrument. Without collaboration each observatory builds what appears to be now the most generally useful instrument—a parabolic reflector—even though there is already a considerable amount of duplication in reflectors of moderate size

The resources of the McDonald and the Yerkes Observatories are sufficient for successful work in many phases of astrophysics They are not sufficient for the development of new fields of research, such as solar physics, objective-prism spectroscopy, the study of cosmic rays or of cosmic radio disturbances. Moreover, the 82-inch telescope is not particularly suitable for certain types of astrophysical research and for which more efficient types of instruments have been designed. In order to enlarge the scope of the work of the McDonald Ob-

servatory it would be reasonable to invite the collaboration of other institutions

Let us suppose that a plan of collaboration could be worked out which would be satisfactory to all participating institutions. We should then be able to organize jointly an observing station in the Texas mountains, where the McDonald Observatory is located, which would be much more powerful than the present McDonald Observatory alone The participating institutions would all profit from the fine climate, which yields nearly 300 clear or partly clear nights each year, from the excellent seeing which averages much better than in the Middle West, from the exquisite transparency of the air at an altitude of almost seven thousand feet; and last, but not least, from the latitude of N 30° which permits the observation of a large part of the southern sky The joint enterprise would benefit from the participation of many competent astronomers whose services no one observatory could possibly afford Duplication of effort, no less than of telescopes, would be avoided Many special types of research which require a large amount of preliminary laboratory work—for example, radio-metric measurements, photoelectric photometry and various other applications of electrical methods—could be prepared at the participating institutions and could be divided among them. Altogether, it would seem to be conservative to say that the plan would increase the observational facilities which are now available to many astronomers and would, thereby, make their present connections more attractive. It is my strong conviction that astronomers and university administrators should seriously consider such a project.

The plan would, of course, be expensive. But it would cost much less than equipment for separate new observatories It would leave the present organizations intact and would secure for each participant a new outlet for research The local observatories could continue their present functions and could, in addition, serve as laboratories for the measurement and discussion of material obtained at the observing station The astronomers would from time to time travel to the observing station in order to gather material They could be available for teaching at all other times and could conduct most of their scientific work in their offices at home. The constant pressure for new telescopes on the various campuses would be materially relieved Measuring machines, photometers, etc, that would still be needed by each institution, would be relatively inexpensive

Although the suggested plan for wider cooperation among astronomers presents some difficulties, they are probably no more serious than those that have already been overcome in carrying out earlier national and international undertakings But, however serious they may be, they should be resolutely met, both because the scientific results to be obtained promise to be very important and because in putting such a plan into effect astronomers will set another notable example of cooperation

WHY WE EAT WHAT WE EAT

By WARREN T. VAUGHAN, M.D.

RICHMOND, VIRGINIA

WHY do we eat what we eat? Possibly this should be preceded by another question, "Why do we eat at all?" The answer is elementary we eat because we have to, because we are hungry Also we eat because we like the taste of things Many a fat old dowager eats chocolate peppermints, not because she is hungry but because she likes chocolate peppermints As a corollary, we also eat because we are in the habit of eating In this country we are in the habit of eating three meals a day The Britisher is not actually a different species of animal that requires four meals daily, but he has found tea and crumpets in the afternoon a pleasant custom and has made it habitual

The same three premises will be found to apply also to the original question. What we eat depends in part upon necessity, in part on habit and in great measure on taste Convenience is also a factor. The newborn babe does not suckle at his mother's breast primarily because he or his mother knows that mother's milk contains most nearly the ideal proportions of protein, fat, carbohydrate and minerals He does so in part because it is the most convenient thing to do. Mother's milk is not an absolutely necessary food Many children are raised, from birth, on cow's milk, and some who are allergic thereto thrive on substitute food mixtures which contain no milk of any sort

Down through the ages, from the earliest savages, dietary habits have been conditioned in great measure by the availability and convenience of the various foods, their palatability and by past experience with them on the trial-and-error basis. Experience has taught us concerning their taste, nutritional value and harmlessness

As we sit in one of the more sumptuous restaurants in a large city and glance over the many pages of the à la carte menu we might wonder to what kind fate we owe our opportunity to order any number of the most delectable concoctions garnered from the farthest corners of the earth Aladdin could not have done as well, since many of the finest of these foods were unknown to him in his remote time We no longer stroke the lamp, but with a few strokes of the pencil we are far better off than he was To-day nearly all of the really good foods on earth are available nearly everywhere, convenient as the corner grocery, palatable as man and nature can render them and guaranteed reasonably harmless by food laws and inspection. A good family dinner of to-day would render a Roman emperor of the banquet era green with envy.

How has this been accomplished? Several years ago an interesting novel started with the collapse of a bridge, the Bridge of San Luis Rey On the bridge at the moment of the catastrophe there were a number of persons, some of them total strangers The remainder of the book traced the former life of each of the victims up to the moment of the collapse, thus bringing to light those forces which gradually brought these victims together for their final destruction. As we sit, ready to destroy the delicacies before us, it would be interesting to trace them, likewise, back to their original sources. Space will not permit discussion of too large a number of our victims, but those

selected will serve as examples for the experiences of others.

Our story must start with earliest times, when more or less isolated groups of the human race were scattered here and there over the earth, and before the words trade and commerce had been invented. Shall we start with the Garden of Eden near the eastern end of the Mediterranean or shall we be more modern and commence on the plateaus of Tibet? Shall we be ultra-modern and assume that those precursors which ultimately became man might, like plants, have started at several places on the earth, provided conditions were right? It makes little difference in the present discussion, although in passing we might point out a fallacy in the story of Eden Tradition to-day has it that the apple was the cause of the downfall Botanists tell us, however, that this fruit had its origin in cooler climates, northern Europe and especially northern Asia. The apricot appears to have been the more likely contender for the honor, since it appears to be indigenous to Asia Minor One might argue that if the apple story is true, the Garden of Eden was not in Asia Minor but more nearly at the site now more widely accepted as the cradle of the human race. Parenthetically, however, the Bible makes no mention of an apple It merely alludes to the fruit of the tree of knowledge.

We might use the apple as an example of the method of propagation and distribution of foods. It seems improbable that all varieties of apple came from a single ancestral tree To-day there are thousands of varieties within this family, *malus*. Some are edible, while others are not. It seems probable that, under proper conditions, plants closely resembling each other and now all grouped within the apple family took their origins independently, in the same way that the wheat of to-day was derived from the wild grasses of Asia Minor, while Indian corn was developing entirely independently from the teosinte grass of Mexico or from another local ancestral grass.

The crab apple of North America is indigenous to the New World and presumably was developing independently while the finer edible apples were evolving in Eurasia But the point to be made is that those varieties which came to be used as foods usually took their origins from some unusually fortuitous specimen and have been distributed across the continents from this original source To-day North America is the greatest apple region in the world We have our indigenous members of the family, most of which are still wild and scarcely edible, but the cultivated apple of North America was originally imported into this country from Europe and more remotely from its original habitat in the cooler climates of the Old World To be sure, man has improved the fruit by fertilization, selection and cross-breeding, until there are now hundreds of more delicious varieties descended from the original parent

But the happy fact is that most of those foods cultivated for use by man may be traced back through historical records to an approximate original source, even though there are inferior domestic varieties which are probably indigenous to particular areas

It makes a rather thrilling picture to visualize nomadic tribes wandering here and there within rather restricted areas; coming by accident upon an unusually delectable specimen of a plant which they have been accustomed to use as food; returning to the same plant whenever feasible, to again enjoy its delicious morsels; and then, as they become less nomadic, taking seeds or cuttings from this particular specimen, to plant in a more convenient place nearer home, nurturing it most carefully, protecting it from the weather and feeding it as it grows, thus establishing the earliest rudiments of husbandry. Into the sequence of the picture,

next comes contact, either peaceful or warlike, with other more or less remote tribes; realization that others have likewise developed better specimens of different foods, and the resulting exchanges by barter or by importation following conquest, this being the first step in the spread of cultivated foods across the earth

Much of this occurred in prehistoric time Carbonized apples have been found in the habitations of the prehistoric Swiss lake dwellers It is true that these may have been the original wild apples rather than cultivated varieties. Apples were known to the ancient Romans and Phoenicians, who raised them in their gardens.

Before the dawn of written history man made a great discovery which enabled him to depart from that nomadism which forced him to change his abode with the seasons, so that he might always be where food was available. The discovery enabled him to remain permanently in one place This was the cultivation of wheat and the making of flour which could be baked into bread for use when fresh vegetables and game were not available.

The origin of wheat is not definitely known, but it appears to have been developed originally from the wild grasses of Asia Minor or Egypt or around the shores of the Caspian Sea. It was introduced into China about 3000 B C. and was described as being present in Egypt about 2440 B C. It was used by the Swiss lake dwellers Fortunately, other groups had also learned to cultivate grasses indigenous to their own territories for use as food Rye is supposed to have originated in the Orient. It has been cultivated by man probably as long as has wheat. Both were used in the Bronze Age. However, rye was not cultivated in ancient India, Egypt or Greece. It is to-day the principal cereal of northern Russia, Scandinavia and northern Germany.

Barley was probably the first crop grain of the human race. It was described in Egypt as early as wheat, and the Egyptians claimed it to be the first of the cereals used by man, introduced by their goddess, Isis. It was a sacred grain to the early Greeks, used in sacrifices and in the cereal festivals. Pliny called it the most ancient cereal. The Cimbri, early progenitors of the Britons, made their bread from barley, which remained the chief food grain of England until as recently as the eighteenth century.

Rice is the most extensively cultivated of the grains and is the principal cereal food for over one third of the entire population of the earth. It appears to have originated in tropical Asia and was introduced into China about 3000 B C. The ancient Romans knew the grain, but it was not introduced into cultivation in Europe until the sixteenth century.

Corn appears to be indigenous to the region of Mexico It has been in cultivation since prehistoric times and is unknown in the wild state Columbus first saw corn in Cuba in 1492 He carried it to Spain, from where it was rapidly distributed to most of the regions of the earth. When the new world was discovered corn was in cultivation from Canada to Brazil and from California to Chili. Some of the Icelandic sagas described as early as 1002 A.D, what may well have been corn on the New England coast. The early explorers following Columbus described the cultivation of corn and lima beans, along with pumpkins, by the Indians in the New England region.

As tribes grew larger and, for economic reasons and purposes of protection, banded together into nations, the distribution of cultivated foods within the nations was facilitated and commerce between them developed. Now, perhaps, we are in the era of the caravan routes across Asia, when trade dealt not only with hides and cloths, precious metals and jewels but also with the less highly perishable of the foods from foreign lands. Chang Chien, Chinese explorer, had established

overland trade routes between China and the Roman Empire by 115 B.C. As the routes of travel, by land and by sea, reached farther and farther, the spices eventually made their appearance in the Mediterranean countries. They were not quickly perishable, and they stimulated the palates of the Europeans as nothing had done before. Almost from the day of their appearance, exploration and commerce were guided in great measure by the desire of the white man for spices and more spices This desire was a potent factor in Columbus' discovery of America, Magellan's circumnavigation of the globe, and the early settlements in America under the British East India Company Love of spices was the cause for many a war. Attila, the Hun, required three thousand pounds of pepper as a part of the ransom of Rome Many were the massacres countenanced in the Dutch East Indies in an effort to retain a monopoly on spices

As the various peoples learned of the uses of their own foods, and their value in commerce, they often made every effort to establish monopolies. On many occasions attempts were made, sometimes successfully, to steal the secrets. An outstanding example occurred, not in horticulture but in sericulture The Chinese had preserved the secret of silk manufacture for many centuries. In 552 A D two monks who had lived for some time in China first smuggled silk worms, in a hollow bamboo, to Constantinople, where, under the protection of the Emperor Justinian, they inaugurated the silk industry in Europe

Coffee was indigenous to Abyssinia, where the natives ate the raw grain as a stimulant. In the fifteenth century the Arabs discovered the value of the bean and started its cultivation in southern Arabia From the port of Mocha, knowledge of it spread to Egypt and Constantinople in the sixteenth century, to Venice and then to England in the seventeenth century. It was then that coffee houses and cafés sprang up in the European centers. Religious zealots denounced coffee as an intoxicating, insidiously pernicious drink The Arabs kept their secret until the eighteenth century, when coffee was grown successfully in Java. To-day Brazil is the world's greatest coffee-producing country.

Chocolate first became known to the white man when Montezuma, the Aztec Emperor, gave Cortez a drink of the delicious beverage from a golden cup. The Spaniards carried cocoa back to Spain, keeping its source secret for many years, selling it at a high price, as chocolate, to the wealthy classes in Europe

Cinnamon, native of Ceylon, was known to the ancient Hebrews, Greeks and Romans, but was not cultivated by them. It was carried across Asia Minor by the Arabs, who kept its source secret for nearly one thousand years

Apricot is native of Armenia, Arabia and the upper portions of Central Asia. The fruit was held in such high esteem that, according to Disraeli, Tradescant joined a crusade against Morocco in 1620 for the sole purpose of stealing apricots for import into Britain. The cultivation of apricots in England dates from that time.

In one way or another, we see, then, that foods relished by one group of persons were gradually disseminated to other parts of the world. At times the route was quite circuitous, as in the case of the Irish potato. This food, native of the mountainous regions of Chili and Peru, was unknown in the hotter climate of Mexico, at the time of the discovery of America From South America it was carried to southern Europe, whence it made its way to Ireland. It was later introduced into New England by a group of Irish colonists. Here was a New World plant, introduced into a different part of the New World via the Old World. In this way it succeeded in passing the

barrier of the tropics, where it does not grow Its cousin, the tomato, made easier progress northward from South America, since the barrier did not prevent its propagation Early explorers found the edible varieties in wide use in Mexico, as well as South America, and according to Jefferson it was being grown in Virginia in 1781. It was not, however, until after 1812 that the tomato came into use as a food in this country. The prejudice against it was probably due to two factors Tomatoes were supposed to be poisonous, possibly because of their relationship to the deadly nightshade Also, the earlier tomatoes which had not been intensively cultivated were by no means as good as they are to-day

The foods which we eat to-day may be fairly accurately traced back to nearly all parts of the world To Asia we are indebted for tea, rye, onion, rhubarb, buckwheat, radish, pistachio, licorice, peach, cucumber, almond, grape and the soy-bean. Tropical Asia has contributed the citrous fruits, rice, cottonseed, egg plant, black pepper, taro (dasheen, coco-yam), mango, mangosteen and endive The islands of the Pacific and Indian Oceans were the source of coconut, bread-fruit, nutmeg and grapefruit If there were no Ceylon we should have no cinnamon. Northern Europe and Asia comprised the birthplace of the edible varieties of apple, fennel, currant and gooseberry, while the mustard or cabbage family—turnip, rutabaga, cabbage, cauliflower, mustard, kohl-rabi, broccoli, Brussels sprouts—are indigenous to northern Europe

From the region of the Caucasus Mountains we have obtained asparagus, quince, pear and plum. Asia Minor and the eastern end of the Mediterranean, where men made such early progress, is fairly well determined as the original home of wheat, barley, shallot, fig, date, English walnut, apricot, olive and artichoke. Garlic, although favored in Italy to-day, took its source from Tartary.

Southern Europe has contributed parsnip, celery, leek, chestnut, filbert, carrot and lettuce. The last may also have been indigenous to the Orient.

Africa has contributed no great quantity of foods, but their quality is good. Spinach is said to have originated in northern Africa, watermelon, cantaloupe and akee from tropical Africa and coffee from Abyssinia. The original home of the oat has been placed both in Abyssinia and the Danube River basin.

The new world has been no mean contributor. From North America come huckleberries, cranberries, pecans, hickory, pumpkin and possibly the kidney bean Cocoa, corn, avocado, peanut, allspice, guava, vanilla, sapodilla, papaya, star-apple, cassava, chocho and sweet potato stem from tropical America, while pineapple, lima bean, Irish potato, tomato, maté and the herbaceous peppers found their origin in South America A few foods were already so widely distributed in a cultivated or semi-cultivated form at the commencement of exploration that their original sources must remain unknown This applies particularly to banana, plantain, ginger and yam.

Nor is the list complete. Within the last half century we have observed many new importations, particularly in our own country, where climatic conditions are so varied that both tropical foods and those that thrive in the cold northern climates may find suitable conditions for growth. The labors of the Bureau of Plant Importation, so delightfully described by David Fairchild in his memoirs, "The World Was My Garden," have made available within our own boundaries many of the most delectable of foods, especially those fruits indigenous to the tropics, such as mango, mangosteen, sapodilla, guava and akee. As time goes on these will undoubtedly come into more wide-spread use, as have their less perishable tropical cousins, orange, grapefruit, banana and pineapple.

The foods that we eat to-day stem from three general sources: (1) those indigenous to America; (2) those imported by the early colonizers from the older civilizations, which in turn had collected them from remote places; and (3) the newer tropical foods which are just making their start

The history of the cultivation of foods parallels the history of the human race However, it has not been until well within historical time that commerce and exploration have made such wide varieties so generally available We read of the banquets of King Solomon and the extravagant feasts of Belshazzar, and of the Roman banquets, some of which are reported to have cost the equivalent of a thousand dollars per guest. Let us sit in at some of these meals

The ancient Hebrews, who learned their cookery from the Egyptians, made quite a ceremony of their feasts Three successive invitations were sent to each guest When all were gathered together they sat cross-legged around a low table The food was mainly a stew, since knives and forks were not available The cut-up morsels were folded by the guest between slices of bread and eaten The grease was rubbed from the fingers onto other pieces of bread, which were thrown to the dogs, waiting as anxiously as they do to-day. Servants were ready with pitchers of water for washing the hands. There were two persons to a dish. The food included flesh, fish, fowl, melted butter, bread, honey and fruit, four or five dishes in all.

The Greeks inaugurated the system of eating in a reclining position, while being sprinkled with perfumes to combat the odor of perspiration They had two courses. The first was fish and meat, vegetables and entrées The second, pastry and fruit, was followed by salty cakes, cheeses and the like to promote heavy drinking This was accompanied by music, songs and slave dances, and garlands were entwined about the heads of the participants "to counteract the action of the wine."

The Romans learned cookery late. In 174 B C there were no cooks nor public bakers in Rome The common people lived on a porridge made of pulse. There were several vegetables. Fish, domesticated animals and wild game helped out The wealthy learned of the luxuries of the table from the Asiatic wars They went mad on the subject of gastronomy The best cooks were the most expensive slaves The Emperor Vitellius, an enormous eater, sent his legions to every part of the empire to procure new and exotic foods In a typical Roman feast the first course, merely an appetizer, consisted of conger eels, oysters, mussels, thrushes served on asparagus, fat fowls, shellfish and marrons The second course had more fish, venison, wild boar and wild fowl The third, or main, course included the udder of swine, boar's head, fricassees of fish, duck and other fowl, pastries and bread. Cheeses, lampreys, tongues of nightingales, brains of peacocks and flamingoes, mushrooms and the rarest vintage wines were served

While Petronius' description of Trimalchio's feast is satirical, we may presume that the foods listed were the delicacies of the time. Also, he could not have mentioned any foods that were then unknown We may therefore list some of the favorite foods of the days of Nero, as follows.

Meats. Sausage, beef, kidney, pork, bacon, lamb, lambstones, sweetbread, liver, chitterlings (present-day chitlings).

Seafood Lobster, pilchard (sardine), mullet, sole, lamprey (an eel-like fish), snail

Fowl Wheatear, goose, capon, blackbird, pheasant, guinea, stork, thrush, peacock, gizzard

Game. Hare, boar, bear.

Fruits Damson, pomegranate, fig, date, apple, peach, grape, raisin, quince, olive

Vegetables. Chickpease, pulse (a legume), scallion (shallot or onion), mustard, beet, lupine (a legume), turnip.

Seasoning. Pepper, vinegar, cumin (a spice of the caraway family).

Nuts. Almond, chestnut.

Sweets. Honey.

Dairy products. Hen's eggs, goose egg, cheese

Confections. Tarts, custards, marchpane, junket, household-bread

This was the day of the vomitoria, when the gluttonous banqueters stepped aside into special rooms provided for the purpose, emptied their stomachs and returned to start again Perfumes, music, dancing, dice, gambling and votive offerings to the gods provided the divertissement.

There must have been considerable monotony to the diet. So many of our more delectable fruits and vegetables were lacking There were no potatoes, tomatoes, chocolate, vanilla, corn, peanuts, pecans, rice or coffee. The list is not complete They lacked many of the spices which are so popular to-day. According to story, garum was their favorite sauce. This was made from the entrails of fish allowed to ferment until liquefied, sort of a prehistoric Worcestershire sauce or anchovy paste This story was told by Horace, who was the cartoonist of the day and inclined to exaggerate It may not be quite true

The Britons learned cookery from their Roman conquerors and from Germanic immigrants.

In the Dark Ages, all Europe forgot how to cook. Charlemagne's banquets were barbaric affairs, with never more than four dishes, chiefly spitted meat. With the Crusades the art was reintroduced, again from the East. The Medici of Florence were chiefly responsible for the renaissance of cooking. Catherine de Medici introduced it into France, where, from the point of view of the epicure, it has remained paramount ever since.

Such, then, is the story of why we eat what we are eating to-day. It is the thrilling history of man, responding first to necessity, later urged on by the need for availability and convenience, and subsequently developing the urge for new tastes and for greater palatability of his sustenance. It is the story of patient husbandry through the ages, of disease and death following trial and error, of avarice, thievery and war. It is the story of exploration and discovery When, to-day, we complain that our soup is not properly seasoned, that our melons are not sweet enough, when we complain of the dryness of our grapefruit or of the sogginess of the sweet potato, let us, instead, give thanks to those unsung heroes of the past whose exploits have made it possible for us to sit each day at dinners such as were never dreamed of by the epicures and gluttons, kings and emperors of bygone days.

VIEWS ON MACHINERY AND UNEMPLOYMENT

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I

IN 1821 the French economist Jean Baptiste Say wrote a series of "Open Letters" to his English contemporary, Thomas Robert Malthus. In one of these letters Say declared that "We who scribble paper in search of truth must be on our guard. if our writings should go down to our grandchildren, the terror with which we contemplate improvements which they will have greatly excelled, may probably appear to them somewhat laughable."[1] This statement suggests that the problem of "the machine" is not of recent origin It antedates by many years the appearance of "Technics and Civilization," "The A.B C of Technocracy" and "Successful Living in This Machine Age." The statement indicates, moreover, that the early economists were interested in the mechanization of industry and its social and economic consequences—and felt impelled to say something on the matter.

Any discussion of "Views on Machinery and Unemployment"—or, more correctly, "Views of Economists on Machinery and Unemployment"—must, therefore, if it is to be at all comprehensive, take us back at least to the time of Say and Malthus Indeed, it must take us back even farther, for the problem of "technological unemployment," to use the modern term, was dealt with by economists for half a century or more before Say wrote his letters.

If serious discussion of technological unemployment goes back that far, to the second half of the eighteenth century, the phenomenon itself dates back very much farther. There is ample evidence to prove that for centuries people have known about, have feared and have tried to forestall the labor-displacing effect of machines The discouraging experiences of William Lee (d. 1610?), who figured out a way of knitting stockings by machine, and of William Ged (1690–1749), who invented a stereotyping machine, can be cited as partial proof of the contention

But technological unemployment as a really serious social problem is not so old. Not until the first stages of the industrial revolution did it take on such a character. While men had been displaced by machines long before the revolution started, it was not until what one might call the "formal" beginning of that tremendous process of change, during the latter part of the eighteenth century, that the volume of such displacement became large, and the amount of comment and controversy centering around it became appreciable In taking up our subject, we shall not be guilty of any serious omissions, therefore, if we restrict ourselves to the "New Era" that began slightly more than one hundred and fifty years ago.

Our method of approach will be primarily topical in nature, rather than chronological, that is, we shall examine various opinions—past and present—on the relationship between machinery and unemployment in terms of certain of their principal features and not according to the date of their appearance. Within each topical section, however, we shall generally proceed in chronological fashion.

II

In their discussions of technological unemployment the early economists emphasized the effect of new machinery on the price of, and the demand for, the article produced. "The introduction of

[1] Letter No. 4, "Letters to Malthus," 1821.

machines," said Sir James Steuart, the Scotch economist, back in 1770, "is found to reduce prices in a surprising manner: And if they have the effect of taking bread from hundreds, formerly employed in performing their simple operations, they have that also of giving bread to thousands, by extending branches of ingenuity, which without the machines, would have remained circumscribed within very narrow limits."[2] Fifty years later Mrs Jane Marcet, probably the earliest popularizer of economics and author of one of the most amusing books in the whole field of economic literature, affirmed that "when any new machine or process whatever which abridges or facilitates labor is adopted, the commodity being produced at less expense falls in price, the low price enables a greater number of persons to become purchasers, the demand for it increases, and the supply augments in proportion, so that it frequently happens that more hands are eventually employed in its fabrication than there were previous to the adoption of the new process."[3] And still later Nassau William Senior, a very capable English economist and professor at Oxford, stated, in terms more emphatic than Mrs Marcet's, that "The usual effect of an increase in the facility of producing a commodity is so to increase its consumption as to occasion the employment of more, not less, labor than before."[4]

Running through most of the early treatments of machinery and unemployment and continuing down to the present day, one will find the reduced-price, increased-demand argument. New machines lead to lower costs of production Lower costs make possible lower prices And at lower prices more units of the article will be sold

[2] Quoted in Arthur Young, "Political Essays," pp 214–5, 1772.

[3] "Conversations on Political Economy," p. 114, third edition, 1819

[4] "Political Economy," p 166, third edition, 1854.

The new machinery, according to the old economists, made possible lower prices. But lower prices were more than a *possible* outcome of the use of the new machines · they were generally the *actual* outcome. The early writers gave little attention to the possibility of prices not being reduced in keeping with the lower costs, and for a very good reason At the time they wrote, competition was very keen The manufacturing and the distributing of goods were for the most part carried on by many small business units, no one of which had any dictatorial control over the prices charged In other words, the competition was atomistic in nature Prices in the market were competitive prices They were sensitive to changes in costs, as well as to changes in demand The introduction of cost-reducing machines, therefore, was likely to be reflected very soon in lower prices for the goods produced. The lower prices would stimulate buying With more units being demanded in the market, more would be produced Men would be needed to make the extra units, and in this way the amount of displacement would be kept at a relatively low level.

The situation during the eighteenth and nineteenth centuries was much different from what it is to-day At the present time, with monopolistic control of one sort of another so widely established, many prices are rigid, fixed more or less arbitrarily by administrative decree rather than by the operation of competitive forces. Under such a condition costs may fall as a result of the introduction of labor-saving machines, but prices may remain stationary When this happens, the amount of technological unemployment is rendered greater, because, with prices the same as they were before, the volume of consumer-demand remains unchanged. The potential market that could be tapped with lower prices continues to exist in a state of dormancy.

That is what happened, for example, during the twenties. Costs were re-

duced in many industries, but prices did not drop commensurately. According to calculations made by the National Bureau of Economic Research, the wholesale price level of consumers' goods dropped from an index of 100.4 for the years 1921–1925 to 100 0 in 1929 (the base year).[5] With costs going down and prices remaining relatively fixed, it is not surprising that profits went up Prof Frederick C Mills has estimated that the aggregate profits of 2,046 manufacturing corporations increased by 90 per cent. between 1922 and 1929 From a base index of 100 in 1922 they expanded to 190 3 in 1929[6]

With so much of the pecuniary gains of technological improvements going to the profit-receivers, rather than to the consumers, new jobs for the workers displaced by the improvements came into existence rather slowly and in what one might call a circuitous manner This helps to explain the presence of a relatively large amount of unemployment during the last few years of "the prosperous twenties"

Present-day students of technological unemployment are greatly concerned about inflexible prices They realize that the disturbing effects on labor caused by improvements in methods and machines are greatly enhanced when prices fail to decline in keeping with lower costs One of their number has gone so far as to suggest that at such a time, and that as far as origin is concerned, "price unemployment" would be a more accurate term than "technological unemployment"[7] This suggestion is of questionable merit—since, if it were adopted, it would seem to be just as logical to call seasonal unemployment that is due to a failure of employers to dovetail their products, "dovetail employment!"—but the fact remains that price rigidity is an extremely important factor in determining the amount of unemployment caused by technological changes

In addition to inflexibility in the commodity price-structure there is at the present time no small amount of inflexibility in the price of labor Wages are not as pliable as they once were Since the days when Steuart and Malthus and Senior wrote their books the free play of supply and demand forces in the labor market has become increasingly restricted Both trade unions and governments have interfered more and more in determining wage levels. Whatever benefits may follow from this sort of action, and it must be granted that they are not inconsiderable, it is an undeniable fact that controlled and inflexible wages may intensify the seriousness of technological unemployment They may act as a direct incentive to employers to introduce additional machinery.

III

From the statements already quoted it is clear that the older economists were well aware of the fact that machines might decrease the demand for labor in particular occupations and that the displaced workers might experience inconvenience and suffering Even the optimistic Mrs Marcet admitted that "The invention of machinery . . . is often attended with much partial and temporary inconvenience and hardship"[8]

While they agreed that the demand for workers in specific trades or occupations might decline as a result of mechanization, the earlier economists—with a few notable exceptions—did not believe that the *total* demand for labor would ever drop

David Ricardo, better known as one of the outstanding members of the so-called Classical School of Economists than as a wealthy stock broker and a member of parliament, was one of the exceptions.

[5] "Statistical Abstract of the United States," p. 312, 1938

[6] "Economic Tendencies in the United States," p 399 It should be added that in 1922 business was just recovering from the first post-war depression.

[7] See *The American Economic Review*, p. 251, June, 1939.

[8] Marcet, *op. cit.*, p 114

Reversing an opinion he once had held, Ricardo, in his famous chapter "On Machinery"—which he added, in 1821, to the third edition of his "Principles" —maintained that the substitution of machinery for labor was "often very injurious to the interests of the class of laborers "[9] The view held by the laboring class "that the employment of machinery is frequently detrimental to their interests, is not founded on prejudice and error, but is conformable to the correct principles of political economy."[10]

According to Ricardo's opinion, it was quite possible for machinery not only to decrease the demand for particular types of labor, but to decrease the total demand as well. It could do this by causing a decline in the "gross annual produce" of the nation. Such a decline, Ricardo affirmed,[11] could not be brought about "in any other way but by a diminished employment of the industrial classes " Stated in another way, Ricardo believed that machinery, by diminishing the gross product of industry, could lead to an inadequacy of real purchasing power, which, in turn, would cause a scarcity of jobs

Ricardo had great confidence in the soundness of his view. That machinery might decrease the total demand for labor appeared to him—he told Malthus[12] —to be "absolutely demonstrable," and in the chapter just referred to he attempted to give such a demonstration. The demonstration was not very convincing, however, and most of Ricardo's fellow economists, as well as most of those who came after him, either failed to subscribe to its logic or went only part way with it.

John Ramsay M'Culloch, a very close intellectual follower of Ricardo and the writer of numerous works on economics, thought it was very plain that every improvement in machinery increased the total demand for labor—thereby disagreeing on at least one point with his master! M'Culloch said that one might imagine a case where machinery had the opposite effect, where it caused a decrease in the total demand for labor, but he felt it could be safely asserted that such a thing had never occurred, and furthermore, that it was extremely unlikely that it ever would occur. He admitted that new machines might decrease the demand for workers in certain occupations, but he did not believe that such a result was serious "It sometimes, no doubt, though rarely, happens that the introduction of improved machinery is injurious to the laborers in particular departments, and that it sometimes obliges a greater or smaller number of them to change their employments " But M'Culloch—of whom, among economists, "it seems to have been given to carry everything to an extreme"[13]—thought that in the majority of industries this change of employment would not be such a great hardship as might at first be imagined, for businesses, he tells us, have "for the most part many things in common" and "an individual who has attained to any considerable proficiency in one, has seldom much difficulty in employing himself in another "[14] It is doubtful if any economist has ever made a more exaggerated statement concerning occupational mobility

Malthus and Senior also took exception to Ricardo's view Malthus did not believe that machinery rendered labor superfluous. When that happened it was a result of population increasing more rapidly than production Senior said that he did not believe there existed "upon record a single instance in which

9 "Principles of Political Economy and Taxation," (Gonner ed.), p. 379.

10 *Ibid*, p 383

11 "Letters of Ricardo to M'Culloch" (ed. by Jacob Hollander), p 114

12 "Letters of Ricardo to Malthus" (ed. by James Bonar), p. 184.

13 John Davidson, "The Bargain Theory of Wages," p 182.

14 For the quotations from M'Culloch see his book "The Principles of Political Economy" (4th ed., 1849), pp. 209, 210, 214.

the whole annual produce had been diminished by the use of *inanimate* machinery."[15]

John Stuart Mill made some concession to Ricardo's opinion when he stated that he regarded as theoretically fallacious the view that the laboring class as a whole could not suffer even temporarily as a result of the introduction of machinery But Mill distinguished between theoretical possibilities and real situations. "Nevertheless," he stated, "I do not believe that, as things are actually transacted, improvements in production are often, if ever, injurious, even temporarily, to the laboring class in the aggregate "[16] Mill recognized the fact that in individual cases machinery causes great suffering, and it was Mill who made the statement, to which all students of technological unemployment must sooner or later be exposed, that "There can not be a more legitimate object of the legislator's care than the interests of those who are thus sacrificed to the gains of their fellow citizens and posterity "[17]

John Elliot Cairnes, who has been called the last of the classical economists, to some extent echoed Mill's views on technological unemployment and to some extent he went still farther than Mill—farther towards "the left " Cairnes pointed out that changes from one method of production or from one system of industry to another are "almost always" (those are his words) accompanied by "more or less temporary inconvenience, and sometimes even with considerable suffering, for those whose occupations have been displaced " And then, after the fashion of Mill, he says "and this is a good reason for society doing all in its power to alleviate and repair these inevitable but transitory evils "[18]

Coming to American economists, one finds that their opinions bear a close resemblance to those of the English economists. Certainly they are not less optimistic in their general tenor. Prof. Arthur Latham Perry, of Williams College, declared, in a widely-used text-book of the seventies, that "the application of machinery to all departments of production, and the introduction of improved processes of every name, can hardly in the first instance be prejudicial to any, and are sure ultimately to be beneficial to all "[19] Perry, it might be pointed out, was greatly influenced by the French economist and publicist, Frederic Bastiat, and the latter's doctrine of "Economic Harmonies" blossoms forth profusely in the words just quoted Everything in the field of industrial technology was working together for good The first impact of technological change could hardly be unfavorable to any one, and the ultimate effects are bound to be favorable to all!

Simon Newcomb, who in addition to his other great accomplishments was an economist of some repute, did not assume the optimistic attitude of Perry—he was well aware of the adverse effects of mechanization on particular individuals or groups—but he asserted that every decrease in the demand for labor in one direction, resulting from a cheapening of production, was offset by an increase in demand in some other direction [20]

David A. Wells stated, in his "Recent Economic Changes," which was published in 1889, "as established beyond the possibility of contradiction," that "all experience shows that, whatever disadvantage or detriment the introduction and use of new and improved instrumentalities and methods of production and distribution may temporarily entail on individuals or classes, the ultimate result is an almost immeasurable degree of increased good to mankind in general."[21]

[15] Senior, *op. cit.*, p. 163.

[16] "Principles of Political Economy" (Ashley ed), p. 97.

[17] *Ibid.*, p. 99.

[18] "Political Economy," p 257

[19] "Elements of Political Economy" (fourteenth ed , 1877), p. 126.

[20] "Principles of Political Economy," p. 390, 1885.

[21] P. 366.

Speaking generally, the non-Ricardian interpretation of technological unemployment, the view that while machinery might decrease the demand for workers in particular occupations, it could not decrease the total demand for labor, ruled among American economists of the nineteenth century as well as among the English economists.

And a very similar interpretation is adhered to by most economists to-day. While they may occasionally veil their real thoughts in an esoterical and misleading use of terms—as when Professor Mentor Bouniatian says that "however rapid it may be, technical progress can not give rise to unemployment or become in any way harmful to the economic life of a country"[22]—they all admit that machines displace men, that is, they displace men in specific trades and occupations, in specific plants and in specific parts of the country But they do not admit that machines displace labor in general In other words, they do not believe that machines are creating a permanent and growing scarcity of employment opportunities

This does not mean, however, that present-day economists feel there is nothing to worry about as far as technological unemployment is concerned A few may take that attitude, but the great majority are of the opinion that here is a problem that requires not only careful analysis but constructive means of control—"a situation," as Godwin long ago pointed out, "that requires kindness and soothing "[23]

IV

As was indicated before, the earlier economists believed that the workers displaced by new machines would not be out of employment for any length of time Their unemployment would be of a short-run nature In the long run they would be reabsorbed. "It seems there are certain speculators, who apprehend danger from the introduction of those machines which shorten labor. But if they sometimes distress the worker it is never for a continuance "[24] This was the view of an early French writer on the subject, and it was shared by most members of the classical school.

The short-run aspects of technological unemployment were not stressed by the earlier writers. This was due in part to the fact that in analyzing this problem—and the same can be said of their treatment of other problems—they were principally interested in the operation of underlying and fundamental forces, and how these, if left undisturbed, would work themselves out Their approach to economics was essentially static in nature, based upon assumptions which made it possible for them, by the method of cold logic, to formulate general principles or laws (Of Ricardo it has long been said, grant his assumptions and you must grant his conclusions) They viewed economic forces as working towards and achieving balance Their economics was of the equilibrium variety. They did not give a great deal of attention to the dynamic, day-to-day, disturbing changes

During recent years, especially since the latter part of the twenties, when the present wave of interest in "the machine" first engulfed us, the short-run aspects of technological unemployment have been more and more emphasized. Numerous studies have been made of the immediate, as contrasted with the more remote, consequences of mechanization The "fugitive" sources of information concerning labor displacement, about which Carroll Wright spoke a half century ago,[25] have grown into a very formidable array Especially notable in this connection are the extensive publications

[22] *The International Labor Review,* p 343, March, 1933

[23] "The Inquirer," p. 196, 1797.

[24] Quoted in Arthur Young, *op. cit.,* p 212.

[25] "The Industrial Evolution of the United States," p. 325.

now being put out by the National Research Project of the Works Progress Administration. With a great deal of additional factual material before us we are now in a better position to discover the true nature of our problem. But it is still necessary for us to make some use of the method of approach adopted by the old economists *A priori* reasoning and long-run considerations are still extremely important. Popular writers may doubt their value, and even ridicule their use, but scientific students of the problem can not neglect them.

V

Against the background of the older views we have just passed in review, and on the basis of evidence we now have at our disposal, it is fitting in conclusion, to present a set of broad, general opinions concerning technological unemployment which as applied to the present day seem reasonable and correct

(1) Technological unemployment is permanent if by "permanent" we mean constantly in existence Technological improvements are always being made, though most of them are actually introduced into industry during years of prosperity, when business and employment are expanding Before all the workers displaced by any one improvement are re-absorbed into new jobs, other improvements are made, and other workers are displaced And so the process continues.

There is, then, what one might call an ever-existing pool of technological unemployment; a pool which has many inlets (there are many separate instances of labor displacement), but also many outlets (there are many openings in industry which "drain off" the idle labor), a pool which has a fluctuating level, but a level which never sinks to the bottom

(2) When it is said that workers who are displaced by machines will in the long run be reabsorbed, two things should be kept in mind. First, the statement refers to the workers displaced by any given improvement; and hence it is quite consistent with the assertion just made about the permanency of technological unemployment. In the second place, "the long-run" is not an absolute magnitude. It can not be defined as accurately as can a pound, a foot or a British thermal unit The term is relative in nature. Its duration varies from time to time, from place to place and from individual to individual If general business conditions are poor at the time that the technological improvements are made, the long-run will be longer than if business is booming If a given locality is in a decadent condition industrially, and if one of its continuing factories puts in new machinery which causes a number of individuals to lose their jobs, the long-run—the time in which these workers will find new jobs—will be longer than if new industries were growing in the community. If a displaced worker is slow in moving to points where jobs are available, or in equipping himself—or in being equipped—for a new line of work, the long-run is longer than if he were more mobile, and more adjustable. The long-run may thus be ten months or twenty months or thirty months or even longer

Here, again, the factor of price should be mentioned, and emphasized. If prices are inflexible the duration of the long-run is extended and the whole problem of technological unemployment, as we have already seen, is rendered more serious.

The term long-run has been called "that face-saving invention of the classical economists!"[26] If it is used and interpreted with discretion the term can not be described in this way, for when it is employed in this manner it becomes a genuinely helpful analytical aid It should be clearly understood, however, that the term is a relative one. Some of

[26] *The Forum and Century*, p 327, June, 1939.

the confusion and disagreement that exists at the present time on the question of technological unemployment is due to a misunderstanding of what the expression means

(3) The amount of technological unemployment in the country varies from time to time, depending on the rate at which technological changes are made and the rate at which the re-absorption process goes on. The situation may be compared to a race between two fictitious beings, "A" and "B" "A" represents the total labor displacement caused by technological changes, and "B" represents the total labor reabsorption In this race "A" is always in the lead. "B" never catches up This means, again, that there is always some technological unemployment.

The distance between the two contestants varies from time to time, however Sometimes "A" takes a spurt ahead—perhaps some especially remarkable improvements are made in machine technology and new machines are introduced into industry in large volume, causing a great deal of unemployment Then "A" may slow down for a while. For economic or technological reasons the speed with which new machinery is put into use slackens up Perhaps the output of the inventors themselves temporarily diminishes The products of their genius and hard work, it is important to notice, do not flow into the market in a steady and regularly increasing stream.

The rate at which "B" moves in the race is also irregular, but not nearly so much so as the pace of "A" The forces bringing about the reabsorption of the displaced workers are in more or less constant operation though they are compelled to act under various difficulties—rigid prices, labor immobility (both occupational and geographical), depressed business conditions, unutilized profits To some extent "B" resembles the tortoise, in the story about the race between the tortoise and the hare. But it differs from the tortoise in two very important respects· its movement is not as steady, and at no time does it pass its competitor. In the race "A" never stops up completely as the hare did—technological improvements are always being made—and "B" is always some distance behind.

(4) Finally, the aggregate volume of technological unemployment is influenced by the ratio that exists between "old-product" inventions and "new-product" ones, between inventions that lead to what has been described as horizontal expansion in industry, that is, the expansion of branches of production that already are in existence, and those that lead to vertical expansion, or the creation of new industries [27]

There is no immutable law which decrees that old-product inventions must lead to a constantly large and expanding body of techonolgical unemployment. But taking the situation as it exists today, with many prices inflexible in nature, and with a rather large degree of labor immobility, there can be no doubt that a predominance of old-product inventions leads to serious and possibly growing technological unemployment.

It is desirable, therefore, to have numerous new-product inventions. It is desirable. But is it possible? That is a question to which many individuals are giving a rather emphatic negative answer. Perhaps their answer is the correct one, though one may doubt it. However, if it is correct, then it seems certain that the amount of technological unemployment in the future will be larger than it has been in the past, unless, of course, prices become more flexible and constructive steps are taken to hasten the reabsorption of the displaced workers

[27] See Professor Emil Lederer's article entitled "Is the Frontier Closed?" in *Social Research*, May, 1939, and the discussion that follows it

TELEPATHY—A SURVEY

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In the last few years there has been a revival of interest in the subject of telepathy. Recently conducted tests have become widely known and discussed It may therefore be of interest to present a short survey of the whole subject, including a few of the clever deceptions practiced and reviewing the psychological and other work which has already been done, and to try to draw some rational and definite conclusions therefrom It might be well to say that the writer of this article has amused himself for many years with sleight-of-hand and legerdemain and has even perpetrated some amateur séances on his friends, so that he can verify from personal experience most of the statements that are here made.

The present interest in the subject seems to have started with two magazine articles[1] written about the tests conducted at Duke University These articles were written in a popular way and brought the tests to the attention of the general public It is doubtful whether such a very wide-spread interest could have been stimulated, if the two articles mentioned had stopped at merely describing the tests The articles, however, made the statement that the Duke tests have definitely and positively proved that such a thing as telepathy actually exists

The subjects of telepathy and clairvoyance have always appealed to the popular imagination and a highly sensational statement of this kind, coming from an authoritative source and backed by apparently reliable tests, probably accounted for the exceptional interest which was created Nearly every one can relate wonderful happenings or coincidences that have occurred and which they can not account for, and many find telepathy a convenient and easy explanation Perhaps we still have left in us some of the reverence for magic and mysticism that our prehistoric ancestors possessed However, an opinion expressed by some casual individual is a very different matter from a carefully conducted test or investigation carried out with the purpose of proving or disproving the existence of telepathy

It will probably be a surprise to most persons to learn that in the last thirty or forty years a great amount of investigation has taken place and that the Duke tests are neither new nor original, they are merely duplicating experimental work already done, particularly that of J E Coover at Stanford University. There have also been several elaborate questionnaires sent out and recorded in great detail Naturally, to form an intelligent belief or disbelief in telepathy, we must not neglect the results already found and the deductions drawn from older investigations

The definition of telepathy is not entirely clear. A better term would be "thought transference", and even this is not entirely satisfactory, for it does not define the mode of thought transference. Crystal-gazing, dreams of certain types, death warnings, premonitions that come true, automatic writing, etc, may be considered as a mode of thought transference. Then, too, telepathy is constantly confused with clairvoyance For example: In the Duke tests, where a num-

[1] Articles by E. H. Wright, professor of English literature, Columbia University, published by *Harper's* for November and December, 1936

ber of cards were placed on a table, face down, and some one tried to name them correctly, telepathy was not concerned. This would be a case of clairvoyance There was no thought transference from one person to another Yet if another person were standing by who knew the positions and what the cards were, then telepathy might have come into action; for the first person might have told the cards by reading the mind of the second person.

It is hard to see how clairvoyance can be explained without considering that it is supernormal. No "natural" explanation will suffice; and so spiritualism and other supernatural explanations have become established beliefs and with some persons virtually religions. Telepathy, on the other hand, does not necessarily transgress natural laws. It is possible to conceive of a "natural" explanation

The *Carnegie Technical Magazine* for January, 1939, carried an article entitled "A Scientific Basis of Mental Telepathy." This article took the ground that it is an established fact that the process of thought is accompanied by the generation of electrical impulses in the brain; and that the brain might be considered as broadcasting a type of radio wave, which might be called a thought wave If this wave were received on another brain in tune with the first, the wave might reproduce the thought. There is nothing in such an explanation to conflict with the conservation of energy

While there are some objections to such a theory, nevertheless the existence of telepathy does not appear to be a logical impossibility; and for this reason scientists seem to be more interested in the demonstration of its truth or falsity than in that of spiritism. This article therefore considers only evidence that is for or against telepathy, and leaves out of consideration the whole field of clairvoyance.

In surveying the field of telepathy one is impressed by certain outstanding facts. First, that all mind-reading demonstrations which have been performed on a public stage and which have been properly investigated have been found to be clever pieces of deception; and second, that all such demonstrations given privately which have been properly investigated have been found to be either fraudulent or, if the performer is sincere, have been explained by some abnormal condition or influence.

The public demand for that which is marvelous has been with us all through history and is responsible for such a man as Cagliostro; but it does not follow that if Joan of Arc had hallucinations she was insincere. In the past fifty years science has undoubtedly taken a good deal of the mysticism out of the world. As the public wants mysticism, their demand may account for the increase in the number and for the particular type of mind-readers that have developed

Let us consider a few representative examples Many public performances are given by conjurers and magicians, who do not claim anything more than a clever piece of deception and so are not convincing; but in many private performances the performer definitely claims that he actually is a mind-reader and is often able to demonstrate his claim in a most convincing way. A good illustration is the following: A few years ago there was a certain Chicago medium who would permit any one to write in his presence the names of six persons, known to the writer but unknown to the medium. Of the six, one was to be the name of a dead person, the rest of living persons These names could be written in any order or way the writer chose. The remarkable part was that the medium was able to select the dead name from the others.

In almost any case of deception there are certain conditions imposed, a careful study of which will sometimes lead to a solution of the mystery. Here there were

no conditions. The test could be performed with any paper or pencil, at any time or any place, without regard to surroundings, kind of light or other restrictions. When this is well done and worked up with proper explanations and supposed reactions felt by the medium, it is a most effective and amazing demonstration of mind-reading.

A detailed description of just how this is accomplished is given by David Abbott in his book, "Behind the Scenes with the Mediums." Suffice it to say here that the secret lies in the length of the pause occurring as the different names are written down. Before starting the medium asked the writer to get in mind the name of a dead person, and then started him writing before he had time to think up the names of the living persons. At the proper time the medium would push and hurry the writer, who in his desire to write quickly would put down that which came easily to his mind; namely, the dead name. There was naturally a hesitation before writing the unthought-of names of the living persons

Such mind-reading demonstrations not only deceive the public, but the trained man may easily be led to believe that there must be an element of truth in it somewhere. Sir Oliver Lodge was one of these notable examples. In the past there has been written a great deal of supposedly scientific literature about such demonstrations. It is of practically no value, because very few researchers have given the time and effort necessary to become familiar with the methods used in such deceptions.

There is one type of public performance where written questions are held in the pocket of some writer in the audience and later answered from the stage Probably the best known of such mind-readers was Anna Eva Fay, who had a considerable vogue and following a few years ago She is largely forgotten to-day, but every now and then somebody tries to revive this type of mind-reading So it may not be out of place to give a few hints about the methods employed.

The ushers in the theater pass pads to the audience to write their questions on. These pads have the second sheet prepared with a very light, invisible rubbing of paraffin After the top sheet containing the question is torn off and kept by the writer, the pads are collected and taken into a secret room, where the pencil impressions left on the paraffin sheets are developed by rubbing with plumbago.

The performer, blindfolded, answers the questions from the center of the stage, where he remains in full view of the audience throughout the readings. In the case of Anna Eva Fay the questions were secretly telephoned to her She had metal plates fastened to the soles of her shoes. Coming up through the stage and flush with its floor were two wires on which she could stand to make the necessary connection Underneath her dress other wires were carried from the metal shoe plates to a small telephone receiver concealed in her hair close to her ear.

As to the questions themselves, there is a well-known technique for answering them The following illustration is taken from a book by Burling Hull on this subject. The questions of course are signed and the performer gives the writer's name and asks him to stand. Here is a typical example:

Performer You are thinking of taking a trip, isn't that so?

Writer Yes, it is

P Do you know any one whose initials are F H?

W Yes, I do.

P It seems as if you were planning a trip to Chicago Is not that so?

W Yes, that is correct

P I want you to think hard of the person whose initials are F. H Is his name Harris?

W Yes, it is

P Is his first name Frank? Tell me if I am right

W Yes, that is right.

P Well, when you get to Chicago you are going to see Frank Harris and you will find everything satisfactory.

It seems to the audience as if the performer had picked these facts out of the air In reality it is merely the way that the information contained in the question itself is presented The question was. "Will I meet Frank Harris when I get to Chicago?" All the information has been given by the question; and although the writer himself knows this he is impressed as well as the audience, because he can not understand how the performer learned what he wrote

Any facts or information that can be gotten about persons in the audience is used effectively Names are looked up in city directories, well-known persons are often in the audience, theater employees are placed among the audience to overhear conversations, etc.

Of late years some wonderfully clever demonstrations of mind-reading have been given Some of the methods employed by Burling Hull are extremely ingenious and impossible to detect However convincing they may seem, all such demonstrations can be run down, and when properly investigated are easily explained, but in some cases it may take an Abbott or a Houdini to do this So what wonder that the average psychologist is completely baffled and does not know what to accept or reject as real? There are a few, but very few, who, like the late G Stanley Hall, are not only psychologists but trained also in the art of the magician and conjurer.

Perhaps the most marvelous demonstration of mind-reading is where a person consulting a medium is told things about himself which the medium could have had no possible means of knowing, even to a secret of his past life that no one but himself knew. A demonstration of this type is known among the medium fraternity as a "reading"; and one medium will ordinarily rate another by how good a reading he is capable of

In order to understand how such seeming impossibilities can be accomplished, we must remember that our attention, like our field of vision, is limited to one thing at a time. We can not distinctly see separated objects at the same time, for our field of vision is too narrow; we must concentrate on one object. Similarly, we can only concentrate a strong attention on one thing at a time. Instances are well known where a soldier going into battle has been shot, in the arm say, and it was some time before he was aware of it His attention was so absorbed by what he was doing that all other feelings and interests were crowded out for the time Several emotions or interests can not exist together, the strongest submerges all the others and will predominate

Furthermore, when we strongly concentrate our attention on some particular thing or event about to occur, not only do we use ears and eyes, but all our faculties are concentrated on it. The consequence is that we are so absorbed in it that we know nothing of anything else that is taking place about us, and will have missed the details leading up to the event that we are so intensely interested in We would be unable to describe anything but the watched-for event Extraneous happenings would have passed unnoticed, and it would be impossible for us to give an accurate description of what took place.

The art of legerdemain is based on this principle It is impossible for any one to describe a piece of sleight-of-hand or a stage illusion, unless they know how it is done, because they describe only that which they put their attention on; and the illusion is so designed that they must put their attention on certain things in order to understand what is taking place They see only what they are supposed to see Their attention is controlled

To come back to the medium and the sitter, as the visitor is called In the first place, the sitter's account of what occurred is entirely unreliable. If the

medium was very skilful, he had so engrossed the sitter's attention with what was about to develop in the conversation that the sitter was unaware of what he himself had said Actually, the sitter supplies information to the medium For example: The sitter and the medium are alone in a darkened room, sitting opposite each other with a small table between them The medium speaks rapidly and incessantly, and with a rising inflection. One can not tell whether he is making a statement or asking a question. He may say, "I feel that you are thinking of a child?" Always with a rising inflection, "I take it to be your child?" It may happen that the sitter has lost a child, and under such circumstances may become emotionally excited If so, some sort of exclamation or reply is sure to come from the sitter Remember the room is nearly dark, and dim phosphorent moving objects and vague sounds may be used to enhance the weird effect

It is natural to reply to questions, and sooner or later people do The reply is immediately seized upon by the medium and followed up with a volley of questions. This has given him a lead, and he pumps along this opening After a little it is quite possible some startling or emotional statement may come out, the content, meaning and development of which has so absorbed the sitter that the detail of the conversation has gone unnoticed and the impression afterwards left is that the medium told these things

It takes a strong skeptic not to give an answer to some of this questioning; and if the sitter is easily affected emotionally and in addition thinks, "Perhaps there might be something in this after all," the results achieved are often truly marvelous

Let us now turn to a consideration of what has been accomplished with experimental testing in psychological laboratories and elsewhere. Here we find scientifically trained investigators and can accept their work without question of their sincerity.

Laboratory tests are generally carried out between two persons, one who submits himself to be tested and the experimenter who conducts the test, often a psychologist The experimenter may conceal an object in his hand and ask the other to guess what it is If the test is card-guessing, the cards may be laid face down on a table in full view of the person tested, or the experimenter and the cards may be a long distance away and his questioning done by telephone

Such tests, however, are subject to certain classes of errors To guard against them is the real problem that the experimenter is confronted with Some persons are subject to hyperesthesia, that is, they are unusually sensitive and receive unconscious impressions, which the questioner may likewise be unconscious of giving Such subconscious and involuntary indications come in many ways Impressions can be given by sounds, involuntary audible whispers, tensions of the body, from light, etc.

The backs of playing or other cards may reflect the light differently enough to unconsciously impress a person who is very sensitive to such a condition. A questioner may unconsciously change the inflection of his voice, to always accompany a question about a particular object. Such inflections can be transmitted over the telephone, where persons are long distances apart.

An example of muscle indication is the old test nearly every one is familiar with, where an object is hidden and then a blindfolded person is brought into the room to find it Two persons who know the hiding place rest their hands on each of his shoulders, and unconsciously and involuntarily push and guide him to it There is also the famous case of Beulah Miller, who apparently possessed telepathic power If some one would count slowly, she would stop him at a number

that had secretly been selected beforehand. She really reacted to the involuntary movements of another person who knew the number.

There is another class of errors or disturbing influences that affect the tests—the habits of mind of those tested, their likes and dislikes, the similarity of thought between persons of like culture and education, etc For example: a person asked to choose one card in a pack of playing cards is influenced by many things, dependent on his type of mind, his reaction to the colors red and black, his preference for high or low numbers, etc.; so that his chance of naming any particular card is by no means 1 in 52. It has been found that the queen of spades is a favorite with many persons. If any one is curious enough to try, they will find that when persons are asked to give a number between 1 and 10, the answer 7 will predominate Among geometrical figures the triangle seems to be the most common choice.

Again, experimenters have found that persons who are being tested will often be keenly sensitive as to whether or not they will be classed as normal. In all sincerity and unconsciously, they may modify their answers in the direction which they believe to be normal.

Speaking of experimental work generally, the principal thing which distinguishes the world of to-day from that of yesterday is the wide acceptance of the scientific method It is the best means of exploring the unknown, and is infinitely more powerful than any method of abstract reasoning We find to-day that our large industrial organizations have elaborate research laboratories and a trained staff of scientific workers. Suppose it were desired to improve certain properties of a steel alloy containing nickel, lead and tin The scientific method says: Make a small sample in the research laboratory, put everything in the alloy as usual with one exception; *viz*, replace the tin with copper. Test this new sample, and if it shows an improvement make another sample with still more copper but without any other change. In the above experiment, every factor has been controlled, and by changing one factor at a time we know positively what the effect is.

In theory we should be able to apply the scientific method to an inquiry into telepathy, but practically it is impossible because all the factors can not be controlled Not only are detrimental influences and errors uncertain, but they may be unknown One of the commonest mistakes is to draw conclusions from experiments where many factors are not under control If one person of a test, say in guessing cards, is more successful than others, it proves nothing so far as telepathy is concerned Why attribute the success to telepathy, when a number of other influences may be responsible for it? If we do not know what the reason is for success, it is just as logical and more so to assume that it is not telepathy Why not some of the "natural" errors explained above, which have escaped observation?

So many precautions must be taken to exclude errors, and so much inconclusive testing has already been done, that the hope of ever being able to control so many uncertain and unknown factors is extremely slight. A scientific test is a controlled test

Another method of treating experimental results is to compare them with mathematical chance Suppose a bag contains one red and one black ball. If we draw one at random the chance of getting either is equal But it is possible that we might draw ten times and get the red ball every time. Yet if we were to draw one thousand times we would draw about as many black ones as red. Mathematics states that as the number of draws approaches infinity, chance approaches certainty Here we are no longer dealing

with individual tests, we are dealing with averages. If the tests are carried into thousands of trials, the averages will become practically constant, and if unaffected by errors will agree with what might be expected from mathematical chance.

An average, of course, can be affected by errors or outside influences, but not as easily as an individual test In many thousands of trials, a few wrong ones do not appreciably affect the value of the average. Errors or detrimental influences would have to persist pretty much throughout to affect an average. In long tests this is not likely to happen The same persons or conditions would hardly continue throughout This method of comparing experimental averages with chance, whatever may be said against it, appears to be the best method we have and the one largely in use to-day Let us look at some of the results found by it.

A huge questionnaire was undertaken about 1895 by the Society for Psychical Research. The object was to find persons who had experienced hallucinations, that is, who had ever had a vision or distinct mental image of a living human being, known to them, and that appeared before them without any apparent physical cause. In all 17,000 replies were collected, and of these 1,300 answered, yes. These 1,300 were then investigated further, to discover how many were death coincidences; that is, where the person seen in this vision died within twelve hours after the time of the vision The result was 30 death coincidences

So out of 1,300 presentiments or premonitions, 30 of them came true. This is 1 in 43 Now the death rate or probability that any given person will die on a given day was found from the insurance tables at the time to be 1 in 19,000 We would therefore assume that if 19,000 persons had premonitions of some one's death, only one coincidence would occur if chance alone acted. Telepathy was therefore considered proven to exist, as the results were (1900 ÷ 43) 442 times what should have been expected from chance

Now, as a matter of fact these figures are very far from proving the existence of telepathy The chance of death, as given by the insurance tables, was determined by considering all kinds and types of men and women Therefore, if this is to be used as a standard of comparison, it can not be applied to any particular class of men and women Manifestly the data collected was from a particular class, *viz.;* those who had experienced hallucinations In other words, the data are not complete or representative; and these figures, if they prove anything, prove only that people of a certain type of mind will reply to such questions, and all the people who did not reply are not tabulated at all

However, what is much more important, many of those who replied may have had, during their life, many other hallucinations These may have been unimportant and for that reason forgotten When mathematical chance is considered, failures as well as successes must be taken into account, and as the failures are not recorded in this investigation, it is absurdly incomplete.

Every one knows the tendency to be impressed by a successful prophecy and to forget the thousands of failures. We all know, and yet we forget the hundreds of prophecies that do not come true How many times has the weather prophet failed; the business improvement prophet, the stock market prophet; all the way down to the palmist and fortune teller! The author of this article, not long ago, had a strong presentiment that something was wrong at his house; but on hurrying there he found every one well and everything all right Probably the next day he would have forgotten all about it, but being interested in this subject he remembered it. So if a presenti-

ment comes to naught, people attach no importance to it and it is forgotten; but let some strikingly vivid or emotional coincidence happen, and it will be remembered always To obtain a record of such failures is therefore an impossibility; and the Society for Psychical Research had really collected only the most meager part of the data needed. How could a committee who were conducting a supposedly scientific investigation base a belief in telepathy on such evidence as this?

Another well-known investigation is one that was instigated by Sir Oliver Lodge Sir Oliver was an eminent scientist, but he was also a believer in spiritualism, to which any of his books on the subject will testify Such, for example, is his "Survival of Man." He had lost a son in the World War, and as this had affected him profoundly, it may in part account for his belief However much Sir Oliver may have known of other subjects, he knew nothing of the medium's art of deception Read any of his descriptions of table lifting, for instance, and any one familiar with the medium's methods will be astonished at his lack of information The consequence was that he was deceived for some twelve years by Madame Palladino and other mediums, until finally Madame Palladino was exposed at a special séance which took place at the house of Professor Lord in Cambridge.

Sir Oliver was therefore the type of man who would be favorable to a belief in telepathy To try to prove its existence he made use of the British Broadcasting Commission to ask questions over the radio. A great many answers were received, some 15 to 20 thousand; but the investigation came to nothing and was finally abandoned by Sir Oliver, in spite of his interest and his desire for some definite results And what else could have been expected? Only a certain type of person will reply to such questions, and answers received will only represent those who are interested and probably favorable to a belief in telepathy. Such results can not be compared with what might be expected from mathematical chance

Probably the most reliable of all such studies was conducted by Dr J. E Coover, about 1917, at Stanford University Every possible precaution was taken, and even some special investigations were carried out to see if certain influences were detrimental. The mathematical treatment was thorough and accurate, and any one will be repaid by a careful study of his publication, "Experiments in Psychical Research at Leland Stanford Junior University."

He tested many persons in guessing lotto blocks, playing cards and other objects, and in no instance, without exception, were the results more than what might be expected from chance He shows many plots of the curve determined from experiment, superimposed on the theoretical chance curve, and it is surprising how close they are together He says in his conclusions on playing-card tests "The results of 10,000 guesses are negative No trace of an objective thought transference is found"

The latest investigation has taken place at Duke University, and great publicity has been given it because it is supposed to have produced a proof of the existence of telepathy The complete tests have not yet been published, but judging from what has appeared in the *Journal of Abnormal and Social Psychology* they are very similar to those of Coover, although much less extensive. The card-guessing tests in particular are much the same, except that the playing cards used by Coover were replaced by cards with special geometrical designs

The mathematical chance or probability curve differs a little from that employed by Coover. Any one interested will find a discussion of it in an article

entitled "New Evidence for Extra-Sensory Perception?" published in the SCIENTIFIC MONTHLY for October, 1937.

The real criticism of the Duke tests is of the data used They were not collected impartially, they are not complete, they are not representative, and of course can not be expected to agree with theoretical chance The method used was to continue a person's testing so long as he made a good score; but when his good scoring fell off he was said to have lost his telepathic receptivity, and his testing was discontinued. That is, they collected the good trials and threw out the poor ones Mathematical chance is not even given an opportunity to operate. Such procedure is merely "loading" the data and of course will give favorable results

Any one who has done any experimental work knows that if a sufficient number of tests are made the average will become constant and any further testing will not change it But in the Duke tests all scores that would modify the average are rejected Under such circumstances it is absurd to use mathematical chance as a basis for comparison

If the Duke tests show some individual repeatedly gives a high score, all well and good, it may be an astonishing fact; but it can not be compared with the results of chance Averages must be compared to chance, not individual or selected cases. The reason averages are used is to reduce the effect of exceptional cases, and if only exceptional cases are considered, all reference to chance must be dropped.

Any exceptional case must be considered on its own merits, apart from chance. It must be positively demonstrated that no error or influence is acting. In a large number of the Duke tests, the cards were both seen and handled by the persons tested; and here is an opportunity for serious error However this may be, to control every factor of a test is a practical impossibility, as already pointed out. This impossibility of proof in exceptional cases has led experimenters to adopt the method of averages Any conclusion drawn where proof is lacking is merely an assumption

The final conclusion regarding telepathy is clear It can be very positively and definitely stated that there has never been any evidence produced which would warrant the belief that there is such a thing as telepathy The most careful and reliable tests show no indication whatsoever of it While of course this is a negative proof, yet after all it is a proof that no such thing as telepathy exists We can positively say that no mind has ever yet communicated with another mind other than through ordinary sensory channels.

STUDIES IN MOSQUITO BEHAVIOR

By Dr. JOHN A. MILLER

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MOSQUITO larvae, or wigglers as they are commonly referred to, are often found in the students' aquatic collections Frequently interest in their behavior prompts a series of questions which either begin with the adverb *why* or end with the preposition *for*. A recent summer school class in zoology composed largely of school teachers was no exception The class reviewed a few elementary facts pertaining to the anatomy of the subjects, then gave their attention to a study of larval behavior

It was observed that most of the larvae left their resting place at the surface of the water in response to vibrations, shadow, temperature, food or variable intensities of light Without prompting, more than one student asked the question, Why? The student answers received as explanations for this behavior are largely responsible for this paper Later in this paper I will describe certain of the apparatus (Fig 1) and give the results of certain experiments.

I think that it is only necessary to quote from several responses written by students to fully justify and warrant a critical analysis of a common misconception of animal behavior It is my intention to emphasize the futility of a teleological explanation of animal behavior.

Mr R The mosquito larvae come to the surface of the water because of their inability to breathe under water The lack of air causes a stimulation which sets up an impulse resulting in the larvae moving about in search of air

Miss S. Because mosquitoes go to the top of the water to get air which is necessary for their life, and the top of the water is always the lightest part, the mosquitoes naturally condition air with light. Therefore when the top of the tube was darkened and the bottom lighted the innocent mosquitoes thought the bottom was the top

It is a well-known fact that the larvae of this species (*Culex pipiens*) leave the surface of the water when a shadow is suddenly cast over them Differences of opinion, however, have been expressed concerning the factors influencing this behavior Holmes[1] states that age makes little difference to shadow reaction, while Stanley[2] found that only 10 per cent of the newly hatched larvae respond to a shadow The percentage of reacting individuals reaches 100 at the age of seven days My observations confirm, in general, the conclusions offered by Stanley.

It is, however, evident that age, temperature and frequency of casting the shadow are factors influencing the percentage of individuals responding In testing shadow reactions the optimum temperature was found to be between 27 and 29 degrees Centigrade and the optimum age between seven and eight days. The number of individuals responding to a shadow repeatedly cast is directly proportional to the interval between casting of the shadow. The writer agrees with Stanley in the observation that the larvae respond negatively to moderately bright light at low temperatures, but react positively to light of the same intensity at optimum temperature. This reversal of tropism occurs at about 15 degrees Centigrade (59° F.). Not only were larvae observed to leave the surface if a shadow were suddenly cast over them, but they also left at the incidence of vibration A knowledge of these facts together with the aforementioned experience suggested the problem

[1] S J. Holmes, *Jour. Animal Behavior*, 1: 29–32, 1911, "Studies in Animal Behavior," pp 50–120 1916. Henry Holt Company

[2] J. C. Stanley, "Light Reactions to Mosquito Larvae, *Culex pipiens*." Unpublished. 1931.

of attempting to determine the factor or combination of factors which are responsible for the behavior of the mosquito larvae with particular reference to surface orientation.

To test certain phases of the problem the following apparatus was designed (see Fig. 1). A glass tube 12 inches in length and 2 inches in diameter was sealed at one end and erected on a standard. This tube was fitted with a black paper sleeve 10 inches in length. The sleeve was in two sections permitting a separation at the center The sleeve could be moved up or down on the tube A Spencer microscope lamp was utilized as the light source and its rays could be directed to the top, center or bottom of the tube as desired Within this tube light and temperature could be controlled and the varying effects studied on larvae of known age.

In the moderate light of the room or when the light of the lamp was directed at the top, larvae were to be found only at or near the surface When the top of the tube was darkened and only the bottom illuminated, the larvae, one and all, migrated to the bottom of the tube Here the young larvae remained and *died* The older and proportionately larger larvae, after all observable movements cease, slowly float to the surface where they recover. It is assumed that this difference is due to a larger supply of air in the bodies of the older larvae, thereby explaining the difference in their specific gravity During the experiment when the light was directed at the center of the tube, the top and bottom being dark, the larvae of all ages congregated in this area. This was a temporary orientation, in that movement into the light area was followed by a movement to the surface and back to the center No larvae were observed to die in this latter situation.

In order to eliminate the air factor at the surface the following procedure was followed. Different age larvae were

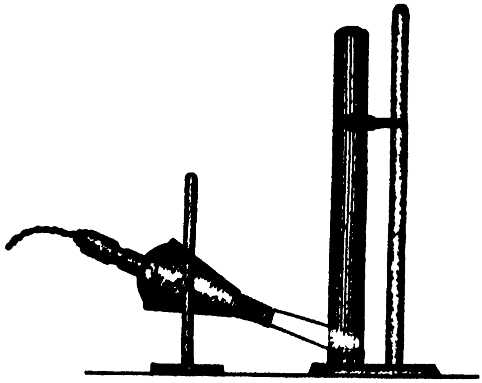


FIG. 1.

placed in test-tubes and attracted to the bottom with a beam of light. During their stay at the bottom of the tube liquid wax was poured into all but the control tubes The wax upon hardening sealed the tubes, leaving no air space above the water Larvae in the sealed tubes reacted similarly to those in the open tubes in their responses to light, vibration and temperature The larvae in the sealed tubes died in a relatively short period of time

Can it be possible that air, with its life-giving oxygen, is of secondary importance in determining surface orientation? If, on the other hand, light and gravity are major factors, what will be the effect of the absence of light from the time of hatching, upon surface orientation and feeding? Frost, Herms and Hoskins[3] state that the food factor is of major importance in rearing mosquitoes in the laboratory Mr William F Bradley, a student of mine, volunteered his assistance in the feeding and rearing of the larvae He was successful in obtaining close to 100 per cent hatch and reached a maximum emergence of 86 per cent. Following is a summary of the feeding experiment, the food being Fleischmann's yeast in suspension in 2,000 cc of distilled water 12 inches deep. The tem-

[3] F M Frost, W B Herms and W. M. Hoskins, *Jour. Exp. Zool*, 73. 3, 461–479, 1936.

perature was 28° C (82° F.) and the illumination moderate

TABLE I

FEEDING EXPERIMENTS

No of larvae	Food per cc	Emergence of adults
50	0 15 mg	00 per cent
50	1 00 "	86 " "
50	5 00 "	10 " "

The following is the summary of a feeding experiment conducted under a variety of light and food conditions, also in distilled water 12 inches deep and with 1 mg of Fleischmann's yeast to 1 cc of water at 27 to 29 degrees Centigrade.

TABLE II

Container	Emergence of adults	Light	Presentation of food	Maximum depth found
No I	None	None	At bottom	5 cm
No II	2 per cent	None	In suspension	15 "
No III	86 " "	Moderate	In suspension	23 "
No IV	12 " "	Moderate	At bottom	30 "

From these observations it is evident that under laboratory conditions it is possible to obtain reasonable emergence when conditions are kept as close to the optimum as possible It should be stated that there is no apparent difference in the percentage of hatching, whether the eggs are kept in the dark or under normal daylight conditions. It is quite evident, on the other hand, that the larvae kept in the dark had little chance of survival. Few larvae were found at any one time in containers kept entirely in the dark

The above table indicates that light (and the absence of light) materially influences the survival through its effect upon behavior Just how deep mosquito larvae will descend was not determined, but it should be noted that they are able to reach bottom (30 cm) When the food is in suspension, larvae are found at a depth of 15 cm when the container is dark, and 23 cm when the container is light When the food is at the bottom, larvae descend to it (30 cm) provided the container is in moderate light, but in the dark a descent of 5 cm was the maximum observed A comparison of the behavior of the larvae in container No I with the activity of those in container No IV suggests that, though food is within the physical reach of the organism it becomes available only to those individuals so activated by an antecedent stimulus, in this instance light.

Discussion: I do not wish to presume any originality for the description of the aforementioned responses of the mosquito larvae. I desire, however, to use this information to illustrate a fundamental principle of animal behavior, namely, that animal behavior is the ultimate result of stimuli upon a particular arrangement of anatomical structure. In the lower organisms many neural motor connections are made in such a way that the ultimate behavior is classed as a tropism According to Loeb, a tropism is the orientation of the body with reference to the source of the stimulus. It is not difficult to find examples of this type of behavior having survival value. But such activities are remarkably stable and inflexible, and given the proper stimulation, the animal continues with a machine-like precision to the end, even though the ultimate result is fatal. The positive reaction of the larvae to light at the bottom of the tube where they suffocate, or in the absence of light their orientation to the surface where they starve are just two examples of the above-mentioned stereotyped behavior The same may be said of the conventional moth and the flame or the reaction of the crayfish upon contacting warm water. (A crayfish will crawl into the warm water (100° F), go directly to the bottom and suffocate; the animal is physically capable of withdraw-

ing from the warm water but without exception remains and dies.) The examples of behavior just described can only be interpreted on the basis of an inherited predetermined neural motor pattern and the organism's inflexible response to a specific stimulus.

Learning, or as it may be called conditioning, was found to play no part in the reaction of the larvae to shadow or to light. Larvae hatched and reared in the dark show the same percentage of response at different age levels as do those hatched and reared in the light The fact that there is a gradual increase in the percentage of larvae responding is indicative of a growth and maturation of the behavior mechanism

The writer disagrees with Stanley when he states that, "the movement of larvae to the top of the water is not a matter of negative geotropism but is clearly positive phototaxis" How can this explain the fact that the larvae rarely leave the surface *except* under lighted conditions? Larvae only travel to the bottom (30 cm) or even half way unless the container is in the light. True, as I have stated elsewhere, mosquito larvae are positively phototropic, but they are just as surely negatively geotropic. The presence of food and, more specifically, its distribution further influences the orientation of the larvae Oxygen, food and water of a tolerant temperature are vital necessities, but more important than these in determining surface orientation are light and gravity Movement beneath the surface may be initiated by an absence of light on the surface with an accompanying light below, by shadow, by food, by vibrations or by lowering the temperature

In conclusion, it would be well to remember that in general the ultimate pattern of the behavior of an organism is the joint product of the stimulus and the specific physical constitution of the reacting individual Further, that in many of the so-called lower organisms the behavior pattern is quite rigid, and even in the higher groups limited in its flexibility It is a precarious statement that assigns purpose, or design, to organic phenomena without consideration of the physical involvements [4]

[4] S O Mast, "Light and Behavior of Organisms," pp 246-260 London Wiley and Sons. 1910

BOOKS ON SCIENCE FOR LAYMEN

CAN THE DISABLED EXERCISE?[1]

THOUGH there are innumerable books attempting instruction in athletics and sports for the normal and physically fit youth, there are few which comprehensively consider the problems of the physically handicapped. The need for such information is obvious, and the title of Stafford's recent book encourages one to feel that this need has at last been met. The majority of previous discussions of exercise for those with physical defects have been theses loyally defending some system of calisthenics with little consideration of the depressing emotional effects of such corrective exercises, or scientific analyses of the exercise problems arising in some specific malady or deformity. Mr. Stafford avoids the first of these limitations and attempts to be comprehensive He frankly recognizes the need for pleasure and satisfaction in recreational activities As a matter of fact, this need is stressed far beyond its true value; the athletic director fails to visualize much if any pleasure in life except through games or sports

The outlined objectives are excellent It is pointed out that such recreative activities should, if possible, attain (1) some corrective value for the particular defect, (2) a minimum of "expectancy of injury" and (3) definite recreational value. The recommendations as to how these desiderata may be attained are less inspired. Those sections of the book dealing with structural or mechanical handicaps, such as amputations, stiffened joints, postural defects and atrophies and paralyses consequent to infantile paralysis, are thorough and instructive. There are many suggestions valuable to physical instructors, parents of crippled children and school nurses. The failure to include the creative handicrafts as forms of exercise invaluable in muscle training and in rebuilding morale is a serious omission. Occupational therapy has long since proven its value in rehabilitation of the physically and/or mentally handicapped. Similarly serious is the total absence of any consideration of sports, games or exercises particularly appropriate for those with defects of vision or hearing.

In addition to these sections dealing with sports for the mechanically handicapped, the author ventures into consideration of the value of exercise and games for a variety of medical conditions. The problems of sports for those with heart disorders are most inadequately considered. While it must be admitted that there is nothing definitely harmful in the suggestions, there is much which may confuse and mislead the lay reader. Anxious parents are invariably prone to believe that which they want to believe. The elementary school discussions of endocrine disturbances were better deleted. A little knowledge can be a dangerous thing and that acquired by scattered reading particularly precarious. Those sections on exercise for the convalescent, for those with glandular disturbances and for those with heart disease are reminiscent of term papers by freshman biology students, devoid of the remotest conception of the significances, limitations and implications of the obvious citations.

EDWARD J. STIEGLITZ

A CATALOGUE OF POISONOUS PLANTS[1]

WHEN an author attempts to make scientific knowledge useful and under-

[1] *Sports for the Handicapped.* By George T. Stafford Illustrated $2 75. 302 pp. Prentice-Hall, Inc.

[1] *Poisonous Plants of the United States.* By Walter Conrad Muenscher. Illustrated. $3.50. xvii + 266 pp. Macmillan Company.

standable to the layman he is not always successful in creating interesting reading. In his recent book on poisonous plants Muenscher has combined information from a great many authoritative sources and has presented it in such a way that it *is* understandable and interesting The work should prove to be of special interest to the cattleman, the agronomist and the agrostologist However, the book is written for reference rather than for general reading and the plan followed makes it more usable to the botanist, perhaps, than to the layman

In the foreword the author indicates clearly his view on the significance of toxic substances in plants when he states (without pausing to comment on his philosophy) that the most plausible hypothesis concerning the role of plant poisons is that they are products of, or "stages in," metabolic processes Thus he divorces the commonly held teleological notion that *toxins are developed for protection* against biological enemies If toxins are stages in metabolism, the physiologist might well ask if some of these substances are not the final stages or end-products of metabolism and are, therefore, wastes or perhaps, in some cases, food reserve

No doubt the reader will be interested and surprised to learn, upon reaching the introduction to the second part of the book, that there are as many as 400 species of poisonous plants in the United States Also he will be surprised to find that this large number of plants is treated in some detail on less than 250 pages of print Such a concentration is achieved, in part, by very concise plant descriptions, augmented by well-executed, faithful, line drawings illustrating seventy-five of the species

A unique feature of the book is found in Part I, where several classifications of poisonous plants are given, based on different criteria After pointing out that certain families (of which there are nine) such as the Ranunculaceae, Solanaceae, etc, include a majority of the poisonous species and therefore might be classed as poison families, the author lists a number of representative plants according to the nature of their toxic principle That is, whether the nature of the toxic principle involved is due to an alkaloid, a glucoside, resinoid, etc Another classification is based on the physiological actions of the poisons blood poisons, neurotic poisons, irritants, etc Among other categories an imposing list (of both scientific and common names) is given of those species (98 in all) which are known to have caused skin poisoning, or dermatitis, together with the part of the plant which carries the toxic principle Unfortunately, the reader who is interested in pollen sensitization will not find a list of the plants which are commonly responsible for hay-fever The classification of poisonous plants is brought up to date by a listing of those species which recently have been found toxic because of their selenium-absorbing habit

In the second part (which makes up the bulk of the book) there is a systematic treatment of poisonous plants by families Of these, two are fern and the remaining ones seed-plant families. In nearly every case the guilty plant is described (sometimes too briefly), its habitat and distribution are given, the poisonous principle is discussed, symptoms of poisoning, and in some instances methods of treatment are outlined

A few shortcomings in so far as the layman is concerned are discovered if one examines the plan of the book and the descriptive material critically with a view to evaluating its usefulness For instance, not knowing the name of a plant suspected of being poisonous, the layman might experience considerable difficulty in learning its identity in this volume Or, it would not be impossible for a layman to confuse a non-poisonous

species with a description of a poison one Again, if the identification of a poison plant were desired and only the symptoms of a case of poisoning were known (as in cattle, for instance) it would be impossible to make safe and certain determinations Obviously the book was never intended to be used as an aid in diagnosing cases of poisoning or as a handbook of symptomatology However, one of the values of the book lies in the fact that symptoms are included in the discussion The taxonomist will agree with the author of the book that a key to poison plants would be of little use unless a key to non-poisonous species were incorporated It seems that the value of the book would have been manifold, however, if a key (in the absence of colored illustrations or photographs of each species) had been included

While the treatment of each species and its poisoning effects in the main is consistently systematic, there are infrequent omissions of flower color and certain other descriptive features which are of great help in making identifications When, as in the case of *Suckleya suckleyana, Ligustrum vulgare* or *Buxus sempervirens* (to cite some random examples), there is no description of flower color or flower form, nor an illustration either, the value to the reader is much lessened Or, as in the case of *Hydrangea arborescens*, where there is no description of the plant nor the behavior and characteristics of the poison described, the reader is disappointed To give space to those plants which cause indefinite and minor physical irritations, or those which by chance flavor cow's milk, may seem unwarranted to those readers who would prefer more information on the strictly toxic species

There has been deliberate limitation of the material in the volume so that only those species are treated which fall into the category of what the layman usually thinks of as plants The poison fungi (wisely), the bacteria (obviously of necessity), and the poisonous algae (because of their relative obscurity, no doubt) are not given a place in the volume There are, of course, practical difficulties which preclude all these groups, yet a student might expect to find reference to some of them in a book bearing the title of this one

In all, the book is very commendable for every reference shelf There is an excellent bibliography, especially valuable since it brings together references to the widely scattered literature on the various aspects of the subject which has appeared since the publication of Pammel's noteworthy "Manual of Poisonous Plants" thirty years ago The index is complete and highly useful, including, as it does, both common and scientific names and some subjects

G W PRESCOTT

TRIBUTE TO A SCIENTIFIC LEADER[1]

As a companion volume to the "Papers and Addresses" of John C Merriam, the staff members and research associates of the Carnegie Institution of Washington have prepared this testimonial volume of papers dealing with investigations of current scientific problems conducted wholly or partly within the institution and illustrative of the principles followed by Dr. Merriam during the eighteen years of his presidency These papers epitomize the past and present nature of the activities of the institution in the various branches of science They, therefore, have an outstanding historical value, since they have been prepared by investigators who are authoritative specialists each in his own field Their reports reflect not only their own accomplishments, but are an index of present-

[1] *Cooperation in Research.* By Staff Members and Research Associates of the Carnegie Institution of Washington Illustrated x + 782 pp. $4 50 and $5 00 (cloth) The Carnegie Institution of Washington.

day knowledge in many of the leading scientific disciplines They also are a record of the results and effectiveness of varying degrees of cooperation among investigators The fields covered are seismology, geophysics, astronomy, terrestrial magnetism, nutrition, genetics, embryology, plant biology, history of science, American history, Mayan civilization and anthropology, early man in America, paleobotany, whales, geology and paleontology A chapter on cooperative research by the editor of publications, F F Bunker, affords a general survey of the policies and procedures followed in the institution A chapter on transmuting science into conservation by N B Doury is a revelation of what leadership has done in saving the redwood forests A closing chapter on John Campbell Merriam as scientist and philosopher by Chester Stock is an appreciation of Merriam's paleontological work and a presentation of his philosophy of life This volume is a fitting tribute to a courageous, constructive and efficient leader and organizer of American science

CHARLES A KOFOID

DRAMA AMONG FOSSILS[1]

THE trustees of the Carnegie Institution of Washington have honored their retiring president by this reprinting of his publications, beginning with his doctor's thesis in 1894, written under Zittel in Munich, and continuing through his comments on the relation between research and organization of knowledge from his closing annual report The four large volumes contain 221 papers arranged according to subject, all reproduced with their plates and text figures They are classified by subject and include papers on the paleontology of Reptilia (24), Mammalia (16), the fauna of the famous tar pits of Rancho La Brea (13), the various fossil faunas of the Pacific states and Great Basin (33), paleontology and human history (18), invertebrate paleontology (6), general paleontology (2), geology (11), the life of past ages (13), history (5), biography (4), general addresses (17), problems relating to nature (30), research and publication (17), research and government (5) and Carnegie Institution addresses and reports (7) A bibliography lists his publications in chronological order

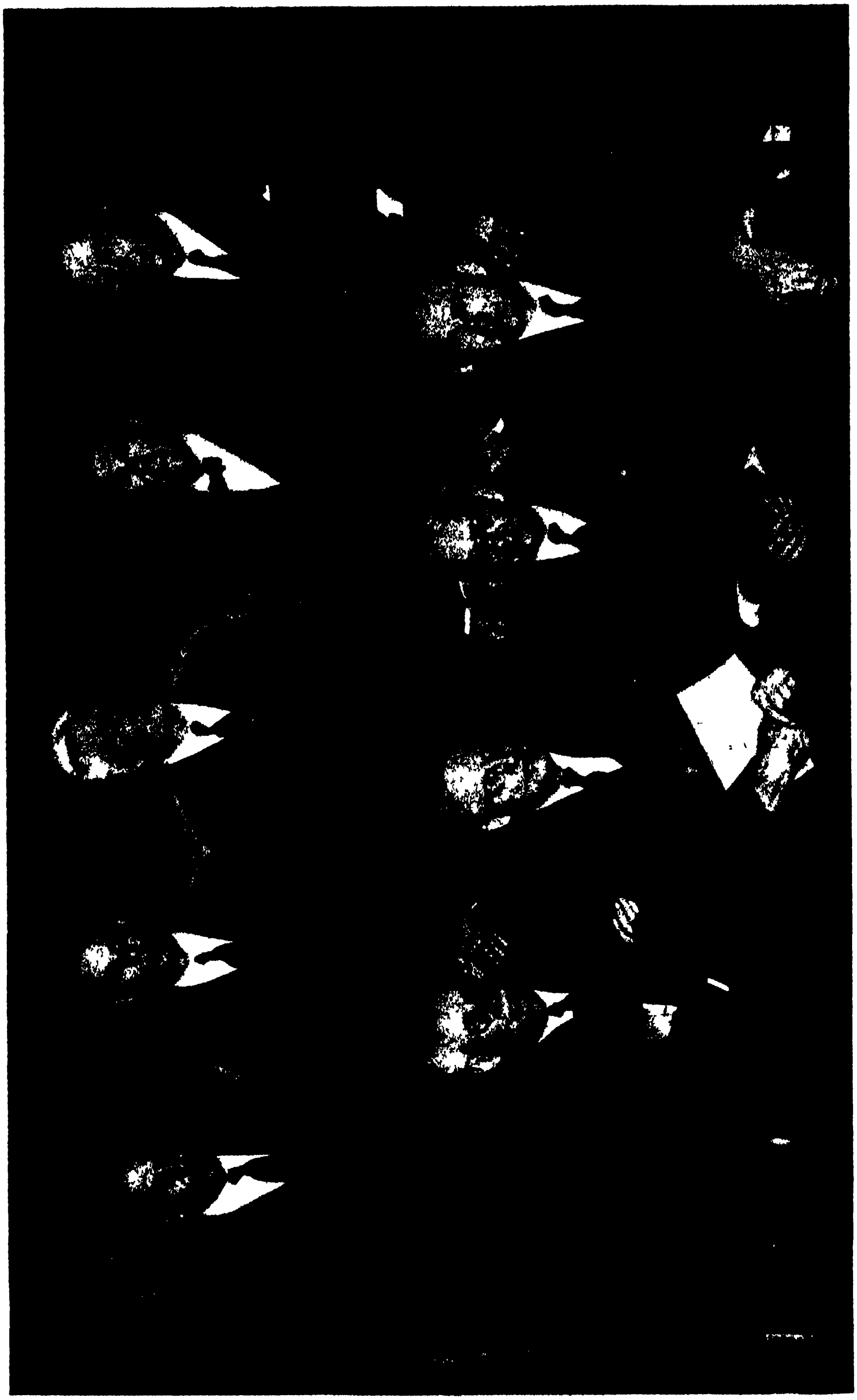
The opportunity to view life in the upper levels of its evolution as revealed in the fossil record has come to few biologists in America of the passing generation with the fullness with which it came to Merriam None has made that record more vivid and scientifically significant nor has any one given more sincere effort to interpret this drama to men who think in all walks of life

The section on problems relating to nature exhibit this and also reveal another phase of activity in relating his scientific knowledge to the conservation of natural reseources and the utilization of the esthetic and educational values of our national parks

The fields included in this assemblage of scientific work and the period in which the work was accomplished are of prime significance in the history of scientific progress in the United States.

CHARLES A KOFOID

[1] John Campbell Merriam Published papers and addresses Illustrated 4 vols $4 50 and $5 00 viii + 2672 pp Carnegie Institution of Washington



THE EXECUTIVE COMMITTEE OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

STANDING SAM WOODLEY, DR ESMOND R LONG DR BURTON E LIVINGSTON, DR J MCKEEN CATTELL AND DR F R MOULTON SITTING DR OTIS W CALDWELL, DR HENRY B WARD DR EDWIN G CONKLIN AND DR. GEORGE D BIRKHOFF

THE PROGRESS OF SCIENCE

THE COLUMBUS MEETING IN RETROSPECT

EVERYTHING worth while appears to be accomplished only at the cost of great effort Consequently it is not surprising that the officers of the association at the time of this writing (January 3) are still carrying a load of weariness acquired at the meeting in Columbus, Ohio, from December 27 to December 30 In those four days, 259 scientific sessions were held for the purpose of presenting the 2,154 addresses and papers which were listed on the programs Obviously no one person could attend all the scientific sessions, for at times from 30 to 50 of them were being held simultaneously Nor could any one be present at any considerable fraction of the 42 luncheons and dinners which were arranged for different scientific groups

Obviously, there are two consequences of such an occasion as the great meeting of the association in Columbus One is the general impressions it makes on those in attendance, the other is the sound additions that are made to established facts and their interpretations Any impressions received at Columbus were from science and scientists as a whole, for through its 15 sections the work of the association covers practically all of science In addition, 41 affiliated and associated scientific societies joined in the meeting, altogether, about 6,000 scientists were in attendance

To me the dominant note of the meeting was that of serene confidence in nature and man Although the world is under lowering clouds of war, scientists walk in the light Although politicians are despairing of the future, scientists have no serious misgivings They know that human beings constitute a young and highly adaptable species They have no fears that wars will sap the biological vitality of the race, for science is saving a much greater number of lives than wars will destroy In fact, the populations of western countries that have the most science, as well as the most destructive wars, have increased with great rapidity during the past century

This optimism was not only a general undertone of the meeting, but it was explicitly and brilliantly expressed by Dr Kirtley F Mather, professor of geology in Harvard University, in his Sigma Xi address on "The Future of Man as an Inhabitant of the Earth" Dr Mather was considering not merely decades and centuries but millions of years From a mountain-top of science he looked back over the geological ages, and forward to a comparable future during which the earth will almost certainly be suitable as an abode for higher forms of life Poets are not the only ones whose "souls catch sight of that immortal sea which brought us hither" or to whom "the meanest flower that blows can give thoughts too deep for tears"

Some of the esthetic aspects of science were delightfully set forth by Dean Marjorie Hope Nicolson, of Smith College, in her Phi Beta Kappa address on "Science and Literature" The poems of the Old Testament keep step to the majestic parades of the sun, the moon and the stars, and sing of the quiet delights beside the still waters The epics of Homer and Vergil and Dante and Milton are heroic portrayals of nature and man, the fundamental subject-matter of science As Dr Nicolson explained, science has given literature some of its noblest conceptions, and literature has added its own beauties to science

But not all the general addresses pertained to such vistas of time or to such esthetic aspects of science This is a practical world, and a cruel world to

those who are not in harmony with its fundamental properties. The programs of several sections of the association and of many of its affiliated societies were concerned with the relation of man to his physical and biological environment But the discussions were not limited to such questions, a considerable number of addresses were upon various aspects of the relations among men Indeed, Dr Wesley C Mitchell, president of the association, chose as the subject of his presidential address "The Public Relations of Science," and Dr Julian Huxley spoke on "Science, War and Reconstruction" Moreover, the Section on Social and Economic Sciences devoted a whole session to the "Effects of Science upon Human Beings" The effects considered in the papers presented at this program were not simply those on human beings as individuals but as members of society Dr Alan Gregg, director of the Division of Medical Sciences of the Rockefeller Foundation, delivered an address on the biological effects of science upon human beings, Dr Isaiah Bowman, president of the Johns Hopkins University, delivered another on the social effects of science; and Mr Lawrence K Frank, of the Josiah Macy, Jr, Foundation, discussed the cultural effects of science These speakers were more acutely aware of the ills that now beset mankind than were those who considered humanity with a longer perspective in time or only incidentally in connection with explorations of the physical and biological worlds

In retrospect the meeting of the association at Columbus was an inspiring success Speaking of the human side alone, it would be difficult to find in all our country an equal number of men and women who are more nearly normal, both physically and mentally, than were the 6,000 scientists who presented and listened to more than 2,100 addresses and papers in four days With pleasant memories of such a wholesome atmosphere and outlook, no feeling of weariness remains

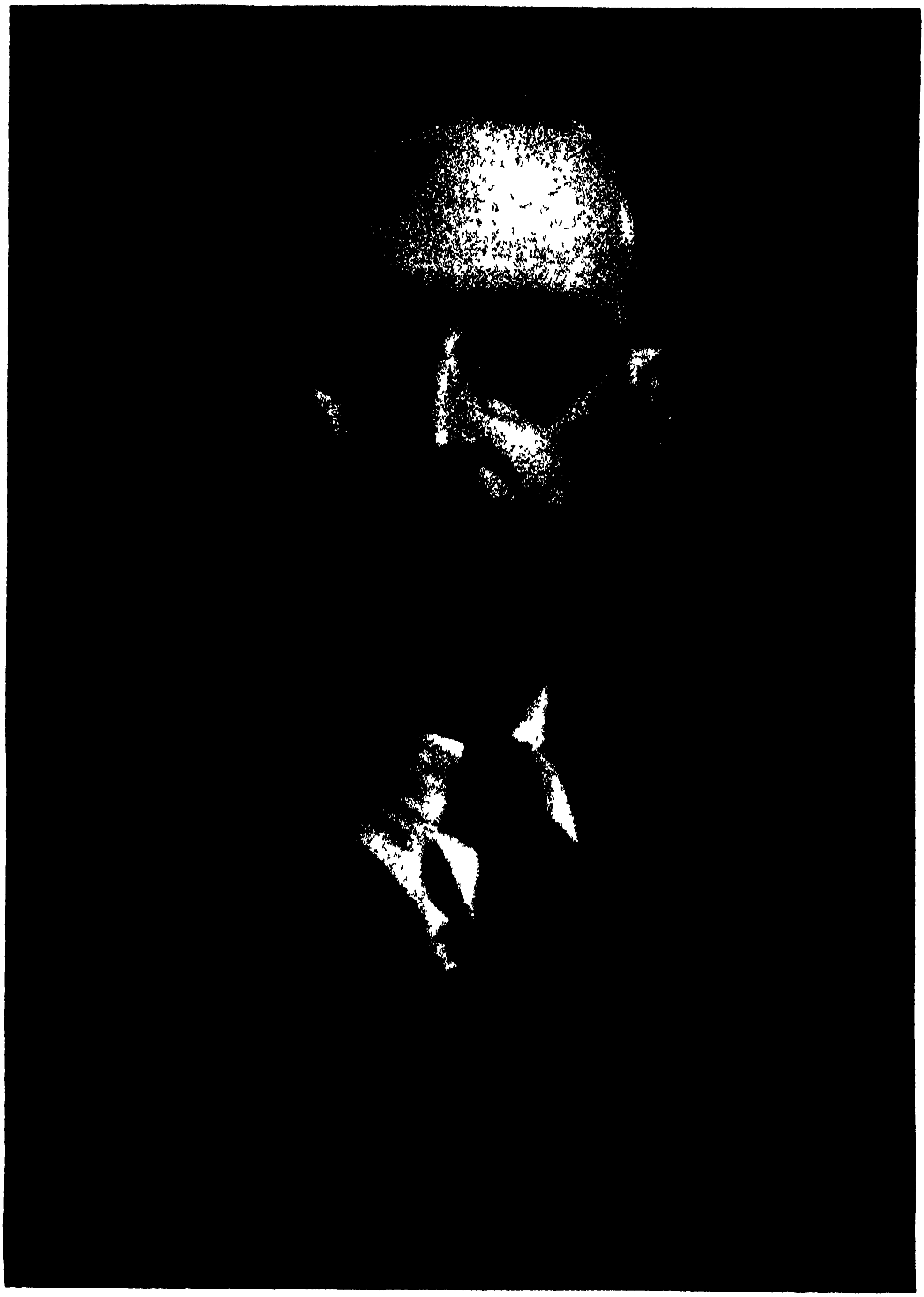
F R Moulton

NEWLY ELECTED PRESIDENT OF THE AMERICAN ASSOCIATION

Active students of biology, especially those whose main interests lie in the field of plant science, have welcomed the recent election of one of their number to the presidency of the American Association for the Advancement of Science for the year 1940 Dr Albert F Blakeslee, the newly elected president, is an eminent botanist of broad interests, best known for his contributions to the physiology of development and reproduction in plants and to the special science of plant genetics It is now thirteen years since a botanist was president of the association

Son of Francis Durbin Blakeslee and Augusta Miranda Hubbard Blakeslee, President Blakeslee was born in Geneseo, N Y, in 1874 He attended East Greenwich Academy, East Greenwich, R I, where his father was principal, and then entered Wesleyan University, at Middletown, Conn, where he received the bachelor's degree in 1896 For the next four years he taught the sciences in Montpelier Seminary, Montpelier, Vt, and in East Greenwich Academy He entered Harvard University in 1900, where he was instructor in botany at Radcliffe College and teaching fellow in botany at the university, receiving the Ph D degree in 1904

In his student period at Harvard he received inspirational guidance from Farlow and Thaxter, who led him to undertake his now well-known study of the Mucors Aided by a research grant from the Carnegie Institution of Washington, he spent the years 1904–06 in further study of the Mucors with Klebs,



DR. ALBERT F. BLAKESLEE

at Halle It turned out that many of these simple fungi are heterothallic, each species existing as two physiologically different strains or races, called *plus* and *minus*, rather than male and female, and that zygospore formation results only from conjugation of the two strains This discovery led to a great advance in our knowledge concerning the nature of the Mucors and also concerning one of the most primitive manifestations of sex

After his return from Germany, Blakeslee held an instructorship in botany at Harvard and Radcliffe for one year and then became professor of botany in what was soon to develop into the Connecticut Agricultural College, at Storrs He held that position—with subsequent change of title from botany to botany and genetics—for eight years, till the fall of 1915 In that period he showed that he was an excellent teacher and cooperator as well as a successful investigator With his classes of forestry students he worked out keys for tree identification in winter, which led to a joint bulletin, with Dr C D Jarvis, from the Connecticut Agricultural Experiment Station, on "New England Trees in Winter" The contents of that bulletin afterwards appeared in book form, as "Trees in Winter" In some attempts to hybridize tree species Blakeslee was successful at a time when little attention had been devoted to that field of study, among other hybrids produced was one from Austrian pine and Japanese pine, one of the very first hybrid pines to be secured in this country

In a waste place at Storrs Blakeslee developed an agricultural botanic garden on original lines, which he described at a symposium held by Section G of the American Association at its Boston meeting in 1909, in a paper entitled "The Botanic Garden as a Field Museum of Agriculture"

On leave from the Connecticut Agricultural College, he spent the year 1912–13 at the Department of Genetics of the Carnegie Institution of Washington, at Cold Spring Harbor, Long Island, in further studies on sex reactions in the Mucors In the fall of 1915, he became investigator in plant genetics in that department, where he has remained ever since When he accepted that appointment he says he intended it to be for only a few years, because he "liked teaching and planned to get back to it" That he never did, but every summer he has conducted a seminar for a large number of assistants Despite his long devotion to intricate research problems, he still loves nothing better than to explain and interpret experimental results and to discuss his thoughts with all who are interested

The long series of remarkably productive experimentation on jimson weed for which Blakeslee and his colleagues, cooperators and assistants are so well known, not only in genetics but also more recently in physiology and horticulture, appears to have derived from those early efforts to set up at Storrs a living agricultural museum A batch of seeds of *Datura stramonium*, received from the U S Department of Agriculture among samples of economic weeds, produced both purple-flowered and white-flowered strains, which served well to demonstrate Mendelian inheritance The "Globe" mutant of this species, found at Storrs in the summer of 1915, was studied after Blakeslee's removal to Cold Spring Harbor, and additional mutants soon appeared Although many plant species were cultured and examined in the next few years, as possibly suitable for intensive study in genetics, Datura seemed most promising in various respects, and it soon became the sole object for thorough investigation in Blakeslee's new experiment garden and laboratory Staff members, assistants and a number of able cooperators all joined in those Datura studies, with many new and important results Unusually good facili-

ties for experimentation were at hand, and Blakeslee's natural penchant for trying new experimental treatments of various sorts seems to have been thoroughly gratified.

Much attention has recently been given to the doubling, quadrupling, etc., of chromosome numbers and to the accompanying physiological and morphological changes in Datura and other plants induced through application of the alkaloid colchicine. This is derived from bulbs or seeds of species of Colchicum (sometimes called autumn crocus by gardeners) native in the region of ancient Colchis—of golden-fleece fame—east of the Black Sea. Because the remarkable effects induced by colchicine treatment are of great economic value to plant breeders as well as to students of genetics and plant evolution, this treatment is now being studied by many workers in many places and its literature grows by leaps and bounds. It has furnished a long-desired key for altering the genetic characteristics of plants, and its employment promises to result in new horticultural varieties of fruits, vegetables and ornamentals.

Among other lines of investigation which have received attention in recent years at Cold Spring Harbor may be mentioned one that deals with the problem of the human inheritance of taste thresholds for such substances as phenylthiocarbamide and mannose. Dr. Blakeslee's demonstrations of his "taste tests" will be remembered by every one who visited the American Association's science exhibitions at New Orleans, in 1931, and at Richmond, in 1938.

Since 1935, President Blakeslee has been director of the Department of Genetics of the Carnegie Institution of Washington. He has received many scientific honors and has been active in many science societies. He holds membership in the National Academy and in the American Philosophical Society. He joined the American Association for the Advancement of Science in 1902 and was elected to fellowship in 1909. He was secretary of Section G (Botany) in 1916–17, vice-president for that section in 1917–18. And now he is president of the association for the year 1940.

BURTON E. LIVINGSTON
JOHNS HOPKINS UNIVERSITY

AWARD OF THE AMERICAN ASSOCIATION PRIZE

EACH year for seventeen successive years, the American Association for the Advancement of Science has awarded its Thousand Dollar Prize to a scientist for work on which he has presented a paper at its annual meeting. The prize at the meeting in Columbus in December was awarded to Dr. I. I. Rabi, of Columbia University. The work of Dr. Rabi throws important light on problems of the constitution and properties of subatomic units.

Any one who keeps even slightly in touch with science is at least vaguely aware of that remarkable body of doctrine known as "the quantum theory." It has achieved very striking successes, but at the price of converting the physicists' picture of the world into something which in parts is very like a surrealist fantasy. If one were asked to choose the most incredible of its features, one could hardly do better than take what is cumbrously called "space quantization." Yet it is this very extravagance of the quantum theory which is now the best attested!

Space quantization is a quality of the elementary particles of which the world is made up, in so far as these are magnets. All electrons and most nuclei (and for that matter, atoms in general) are magnets. They are magnets by reason of the fact that they comprise rotating

electrical charges, for the spinning or rotation of a charge-bearing body converts it into a magnet Also by reason of the rotation or spinning, the electrons and the magnetic nuclei have angular momentum The startling quality of which I have to speak is a quality of angular momentum really, but so closely linked is this last with the magnetism, that it will be excusable as well as convenient if from now on I call it a quality of the magnets

To state it briefly, then, this fantastic quality is the following these elementary magnets, when in a magnetic field, are constrained and obliged to incline themselves -- "orient themselves," we say-- in one or another of a very few permitted directions The electron and the proton are obliged to choose between two "permitted orientations", these bear the descriptive names of "the parallel orientation" and "the anti-parallel orientation" The deuteron enjoys three possibilities, those two and "the transverse orientation" There are more complicated cases, but we shall not consider them

DR I I RABI

Nearly twenty years ago the physicists Gerlach and Stern undertook to test the notion of space quantization, by projecting a jet of silver atoms horizontally through a vertical magnetic field Had the field been uniform, the jet would have been unaffected, for each atomic magnet would have found its north pole pulled upward just as strongly as its south pole was being pulled downward, and the net force would have been nil The field, however, was designed to increase very rapidly in strength in the upward direction, and therefore any atomic magnet traversing it found one of its poles subjected to a stronger field than the other pole, and consequently suffered a net force upward or downward In this non-uniform field the jet of silver atoms was divided into two, one consisting of atomic magnets with their north poles pointed straight up the field, the other of magnets with their north poles pointed straight down the field There were no intermediate cases, and the most incredible assertion of quantum theory thus became an undoubtable fact! (One of the experimenters has since admitted that when he planned the experiment he expected it to confute the theory, not to substantiate it) This particular result refers to the electron, since the silver atoms play here the part of inert carriers of a single electron which alone is oriented

This is the method of experiment which Rabi and his school have refined by an amount comparable with the progress in the making of spectroscopes from Fraunhofer's grating of wires to the ruled gratings of the twentieth century With the method thus refined they have made a remarkable variety of striking experiments and significant measurements But to introduce the result reported by Rabi at Columbus, I must now remove the implication that as one of these magnets is passing through a field, its orientation is irrevocably fixed So it was, in all the experiments up to 1937, but Rabi conceived how to make the magnets change their orientations midway in their flight Now in changing their orientations, they either lose or acquire energy, since it requires work to alter the inclination of

a magnet with respect to a magnetic field. If the change of inclination is in the sense corresponding to loss of energy, this lost energy is radiated in the form of a photon or corpuscle of light The loss of energy is so very small that the light in question often belongs to the range of wave-lengths which ordinarily we do not consider as being light at all, but rather as radio waves What Rabi therefore conceived was a method for producing radiations from atoms and molecules, which often are of radio frequencies

The method serves not only for producing these rays, but for detecting the "transitions"—i e, the changes in orientation—which produce them, and for ascertaining their wave-lengths, the magnetic moments of the magnets and a host of other details of the molecular structure As the jet pursues its course through the magnetic field, it passes through a region where an oscillating radio-frequency field can operate on it At certain critical frequencies—or let me say critical wave-lengths—the transitions occur The molecules which undergo them follow altered courses through the remainder of the magnetic field, and therefore miss the detector, which is so placed as to catch only those which are unaffected At the critical wave-lengths the detector thus reports a falling-off in the strength of the jet These are the wave-lengths of the rays which the particles emit or absorb When they are measured, the magnetic moments of the reoriented particles can be calculated

Now I must say what these particles are The experiments were performed on hydrogen molecules, each containing as its pair of nuclei either a pair of protons or a pair of deuterons or one of each The re-orientations which are discerned are those of the protons and deuterons, sometimes turning singly and sometimes turning as though welded into a single rigid whole Here the molecules are serving as carriers for orientable nuclei, as in the Gerlach-Stern experiment the silver atoms served as carriers for orientable electrons (and, by the way, Rabi at Columbus described observations on the re-orientation of such electrons) The magnetic moments of the proton and the deuteron are computed with accuracy hitherto undreamed of, while finer details of the phenomena reveal the interactions between the two nuclei of the molecule, as also those of the nuclei with the revolving electrons which complete the molecule For those to whom the terms "spectroscope" and "Zeeman effect" are familiar, I may say that the molecular jet passing through a system of cleverly designed magnetic fields now becomes a spectroscope of resolution far surpassing the best optical device and is applied in these experiments to a Zeeman effect of extraordinary smallness and subtlety

KARL K DARROW
BELL TELEPHONE LABORATORIES

SYMPOSIUM ON BLOOD, HEART AND CIRCULATION

TO-DAY heart disease stands first in the list of the causes of death Therefore, it was most timely for the Section on Medical Sciences of the American Association for the Advancement of Science to initiate and organize as its contribution to the annual meeting at Columbus, Ohio, a symposium on the blood-vascular system The layman is quite callous and complacent to the oft-repeated accounts of the achievements of modern medicine in preventing and controlling such age-old plagues as yellow fever and smallpox, maladies which the majority of our younger clinicians have never seen, and now, confronted with mortality statistics,

raises the question as to what is being done about heart disease

During the four decades or more that have passed, laboratory and clinical investigation has increased by leaps and bounds, and in this forward march of progress cardiovascular research has been in the front rank One may consider as an example the field of electrocardiography Einthoven, a physiologist of Leyden, not only designed the string galvanometer, but employed the electrocardiograms obtained by the use of this instrument in the diagnosis of simple arrhythmias, hypertrophy of cardiac chambers and changes in position of the heart Sir Thomas Lewis and his pupils extended the work to include curious ventricular beats and many obscure rhythms and sequences of the heart Since these epoch-making experiments, the pendulum has swung across the Atlantic, and to-day leadership in the study of the heart rests in our midst As a matter of fact, American eminence stands out conspicuously, and many of the foremost contributors in their fields participated in the program at Columbus

Forty papers in the nature of reviews were prepared for the symposium Eight dealt with various aspects of the composition of the blood In one, attention was directed to the recent advance made in controlling hemorrhage as a result of the discovery and isolation of vitamin K This substance is essential to the production of prothrombin, which plays a definite rôle in the clotting of blood The administration of vitamin K has important implications in the field of human therapeutics, particularly with those individuals born with the tendency to bleed (hemophiliacs) A second paper considered the mechanism of antibody formation in susceptible hosts For nearly forty years physicians have been injecting suspensions of dead bacteria and their products into man and animals in order to stimulate them to provide their own defensive mechanism against diseases such as typhoid fever and diphtheria The efficacy of the procedure is manifested by the present low incidence of these scourges of former years Coincident with the development of immunity, protective antibodies appear in the blood, it is their presence that forms the basis for borrowing immunity for therapeutic purposes from specially treated horses or in certain instances the serum of convalescents The actual site of antibody formation has been an enigma, but Dr Florence Sabin with the aid of a highly colored synthetic chemical compound feels she has found the answer to the problem The foreign material, following its introduction into the body, is carried to or attacked *in situ* by cells of the reticulo-endothelial system These cells, which are concentrated in such places as the lining of the liver sinuses, in the spleen and bone marrow, then dissolve the foreign agent and in turn synthesize and liberate into the blood stream from their cytoplasm immune globulins, the protective agents

Of all the organs in the body, the heart has had the most attention by clinicians, for, when the heart stops, the patient is pronounced dead The first of the papers devoted to this organ was a detailed account of the main coronary arteries, those vessels which supply the blood to the heart muscle itself The coronary artery pattern is not the same in any two human hearts and may in general be placed in three groups depending on what coronary artery predominates in the blood supply to the heart Hearts which are supplied mainly by the left coronary artery are most susceptible to coronary arteriosclerosis, while those in which both the right and left arteries function properly are least susceptible to this disease Many factors influence the flow of blood

through the coronary vessels, although it would seem that the purely mechanical ones are the most important

The possibility of the production of cardiac lesions by non-penetrating wounds to the chest, particularly in connection with modern automobile accidents, is giving the clinician considerable concern It appears from the experimental evidence that the apprehension is warranted, since slight hemorrhage and contusion of the various parts of the heart are actually associated with non-penetrating injuries The possibility of fatal arrhythmias developing following external chest injury without pathological evidence of cardiac injury was demonstrated in dogs and postulated in man

Shortness of breath, or dyspnea, is recognized by the laity as well as the medical profession to be a most common symptom of heart disease Investigations point clearly to congestion of the lungs, a sequela of heart disease, as the most important cause of dyspnea

The final papers on the symposium were devoted to the subject of hypertension, or high blood pressure Physiologists and clinicians have linked the kidney with this condition for many years without an adequate understanding of the mechanism involved The evidence suggests the association of persistent hypertension with a variety of renal injuries, the ultimate cause being humoral rather than nervous in origin The old belief in "renin," a renal extract, as being responsible for the development of hypertension is now questioned, and in its place there is the possibility that the absence of a humoral agent from the diseased kidney may play a part in the production of this condition

The symposium was an outstanding success It afforded an opportunity for both clinicians and laboratory workers to meet and discuss their common problems The clinician confronted in his practice with unusual conditions must find their solution in laboratory experimentation In the past the practitioner has not used, particularly in connection with heart disease, the findings of the laboratory workers, and it is only when opportunities for free discussion are provided that advance will be made in the conquest of the leader of the causes of death

MALCOLM H SOULE
UNIVERSITY OF MICHIGAN

THE SCIENTIFIC EXHIBITION IN COLUMBUS

AT its annual meeting each year, the American Association for the Advancement of Science has a scientific exhibition participated in both by scientists showing their latest researches and by publishers of scientific books and the manufacturers of aids to scientific research The science exhibition at the Columbus meeting of the association was a fine success Dr Farr, of the Boyce-Thompson Institute for Plant Research, who presented one of the most interesting research exhibits, writes as follows

> May I take this occasion to express to you our appreciation of the facilities offered to our department in connection with the recent Annual Exhibition of the American Association for the Advancement of Science The effort which had been expended in preparing the material for our exhibit was more than fully repaid I know of no other plan in effect which succeeds so well in fostering constructive and uninterrupted discussion of research data in the presence of research material than that offered through the medium of the Annual Exhibition

And a scientific equipment company, which has been an exhibitor at meetings of the association for more than ten years, says

> May we say a word of appreciation at this time for the very noticeable improvement in the atmosphere in the convention hall The result was more natural and there were more friendly conversations, and more opportunity for the professors to ask questions and for us

A VIEW OF THE SCIENCE EXHIBITION
FROM THE BALCONY OF THE AUDITORIUM, SHOWING THE SCIENCE LIBRARY IN THE BACKGROUND

to answer them as completely as possible without interruptions

The policy of the association, to combine research and scientific-commercial exhibits, seems to have met with approval It was interesting to find a Nobel prize winner exhibiting side by side with a company which supplies men of science with the media for their work The association appreciates the cooperation of those who participated in what is probably the most unique semi-commercial exhibition in America [1]

It is to be regretted that the fine exhibits of some of the exhibitors specializing in the chemical field did not re-

[1] American Association for the Advancement of Science, Bakelite Corporation, Battelle Memorial Institute, Bausch and Lomb Optical Company, Biological Abstracts, The Blakiston Company, Boyce Thompson Institute for Plant Research, Carnegie Institution of Washington, Department of Genetics, Fred S Carver, Central Scientific Company, Chicago Apparatus Company, Clay Adams Company, The Coleman and Bell Company, Commercial Solvents Corporation, Denoyer Geppert Company, Eastman Kodak Company, The Exact Weight Scale Company, Ford Motor Company, Gradwohl School for Laboratory Technique, Graf-Apsco Company, Guthrie Clinic, Robert Packer Hospital, Dr Robt T Hance, Duquesne University, Institutum Divi Thomae, Dr Chas T Knipp, University of Illinois, Leeds and Northrop Company, Dr B J Luyet, St Louis University, McGraw-Hill Book Company, The Macmillan Company, Merck and Company, National Geographic Society, The Ohio State University and Cooperating Institutions, Phonetics and Chemical Abstracts, Engineering Experiment Station, Industrial Research Foundation, Prentice-Hall, Inc , W B Saunders Company, The Science Press Printing Company, Seoscope, Incorporated, Society for Research on Meteorites, Spencer Lens Company, Student Science Clubs, Vassar College, Department of Botany, U S Bureau of Plant Industry cooperating with the Biological Institute of Sao Paulo, U. S Department of the Interior, Geological Survey, U S Housing Authority, University Presses, Virginia Agricultural Experiment Station cooperating with Duke University and North Carolina Department of Agriculture, W. M Welch Scientific Company, John Wiley and Sons, Incorporated; Wilkens-Anderson Company, The Williams and Wilkins Company.

ceive all the attention that was desired This was probably due to the inclement weather and the fact that the research exhibits in chemistry were held at the Ohio State University, at a distance of several miles from the general exhibition hall

The Science Library, the purpose of which is to display scientific books published during the year, has become increasingly popular It provides an unequalled opportunity to examine the year's books in all fields of science

O C

THE WASHINGTON DINNER IN HONOR OF JULIAN S. HUXLEY

ONE of the important functions of the American Association for the Advancement of Science is to diffuse science among men That is also one of the chief functions of the Smithsonian Institution and the primary function of THE SCIENTIFIC MONTHLY Consequently the Association, the Smithsonian Institution and THE SCIENTIFIC MONTHLY arranged a large invitation dinner in honor of Dr Huxley, which was held in Washington on the evening of December 2 At this dinner Dr Huxley spoke brilliantly on "Science, Natural and Social" Of course, only a brilliant address could be expected from a man of such distinguished family and of such varied and exceptional accomplishments He is a grandson of the great T H Huxley, a contemporary of Charles Darwin and an unanswerable advocate of biological evolution, a man whose public addresses were so brilliant that they drew distinguished writers and clergymen and

DR JULIAN HUXLEY

PHOTOGRAPHED IN THE OFFICE OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, SHORTLY AFTER HIS ARRIVAL IN AMERICA

AT THE DINNER IN HONOR OF DR HUXLEY

DR JULIAN HUXLEY, DR F R MOULTON PRESENTING DR BOWMAN TO THE AUDIENCE, AND DR ISAIAH BOWMAN WHO INTRODUCED THE GUEST OF HONOR THE LADIES AT THE EXTREME LEFT AND RIGHT ARE MRS. BOWMAN AND MRS MOULTON

lawyers for the pleasure and advantages they obtained from listening to a great master of style Dr Huxley is a grandnephew of Matthew Arnold, critic and poet, nephew of Mrs Humphry Ward, novelist, son of Leonard Huxley, biographer and historian, and half-brother of Aldous Huxley, essayist and novelist

One feature of the dinner made it a memorable occasion Dr Isaiah Bowman, the first lecturer to Great Britain under the arrangement between the American Association and the British Association, introduced Dr Huxley, who at the time was scheduled to deliver, three weeks later at Columbus, the first British lecture before the American Association Thus fortune and forethought brought together at a dinner in their honor in Washington the first two exchange lecturers of two of the greatest scientific organizations in the world, one British and one American It is hoped that on similar occasions in the future scientists of many countries will join in considering the problems of civilization

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THE FUTURE OF MAN AS AN INHABITANT OF THE EARTH[1]

By Dr. KIRTLEY F. MATHER

PROFESSOR OF GEOLOGY, HARVARD UNIVERSITY

I

During the first decade or two of the current century, geologists, astronomers and physicists engaged in many discussions concerning the future of the earth as an abode for life Some believed that "the end of the world" was relatively close at hand, others, that the prospect for the future was to be measured in terms of hundreds of thousands if not of millions of years. As usual in scientific circles, there has emerged from the conflict of ideas during the years of discussion a general unanimity of opinion, and to-day the geologic outlook for the future of the earth is quite clear

Since the turn of the century new methods of measuring the length of geologic time have been discovered and applied. New concepts of the nature and sources of energy have been proposed and tested. New data concerning astronomic space and the distribution of the stars have been secured. Innumerable details of earth history have been deciphered to give a trustworthy record of the changes which the earth and its inhabitants have undergone in the past. The key to unlock the secrets of the future is now available in this knowledge of the past, and with our present understanding of the processes of nature that key may be intelligently used All the evidence combines to lead us unmistakably to the conclusion that for many scores if not for hundreds of millions of years to come the earth will continue to be a comfortably habitable abode for creatures like ourselves

Surface temperatures of the earth, the most important item in any consideration of its long-range habitability, are determined by the receipt of solar energy distributed through atmospheric agencies For any given area of land the annual contribution of heat from the earth's interior, hot though it may be, is just about equal to the warmth received from the sun in twenty minutes by an equal area in equatorial latitudes under a clear sky at mid-day The nineteenth-century picture of an earth, initially fiery hot but progressively cooling so that yesterday it displayed a glacial climate and to-morrow it will be too frigid to support life, may now be thrown into the discard. The earth will "grow old and die" only as a result of failure to receive adequate supplies of radiant energy from the sun. The prospect that the sun will "burn itself out" in a decrepit old age is so remote as to baffle all attempts to date that untoward event even by those who are expert in manipu-

[1] An address delivered under the joint auspices of the American Association for the Advancement of Science and the Society of the Sigma Xi at the Columbus meeting of the association.

lating astronomic figures. Nor is there any likelihood that the space relations between earth and sun will change appreciably within scores of millions of years and put the earth either too close to the sun or too distant from it for comfort

The lurid pictures of a sudden catastrophic debacle resulting from collision with some other heavenly body—comet, planet, star or what you will—are products of a vivid imagination wholly without foundation in astronomic fact or theory.

The only plausible alternative to the conclusion that earth and sun will continue the even tenor of their ways for an inconceivably long period of time is that the sun will some day imitate the super-novae occasionally detected among the stars and terminate the existence of the entire solar system by a gigantic explosion Precisely one such super-nova has been observed within the galaxy of the Milky Way and several such in all the other galaxies of stars during the past few decades The astronomers could therefore calculate for us the chances on a statistical basis that any individual star—the sun, for example—would suffer such a fate within any given period of time. The result would be a figure so infinitesimal as to set at rest the mind of even the most jittery of questioners Pending the discovery of the kind of premonitory symptoms displayed by stars about to blow themselves to atoms, the best that can be done is to rest content in history Since the earliest records of living creatures were left as fossils, if not indeed since the earliest sedimentary rocks were formed, the sun has faithfully maintained its energy output within a fairly narrow range and has given no evidence of any fluctuations that might suggest any significant change in its behavior.

The geologist may therefore turn with confidence from the long perspective of geologic past with its one-and-a-half to two billion years of recorded earth history to a similarly long prospect for the future. Time is one of the most overwhelming resources of our universe.

It should not be inferred, however, that the earth will continue in the future to display the same environmental conditions as those which we enjoy to-day. The history of mankind thus far has been enacted against a background that in the full perspective of earth history is truly extraordinary The geologic period in which we live is a time of unusually rugged and extensive lands with notably varied climate ranging from the glacial cold of Greenland and Antarctica to the oppressive warmth and humidity of certain equatorial regions Such conditions have apparently recurred many times at long-spaced intervals since the oldest known rocks were formed, but added together the time thus represented can not be as much as a fourth of geologic time Much more characteristic of earth history as a whole have been the conditions illustrated by those periods when corals thrived in shallow seas occupying the site of Baffin Land and North Greenland, and coal-forming plants flourished on Antarctica. The probability is strong that eventually, say in five or ten million years, the earth will display again the physical conditions of many past geologic periods that were characterized by broad low lands, wide shallow seas and uniform genial climate

But most of us have a greater interest in the next few centuries than in the subsequent millions of years Minor changes in climate will doubtless occur just as they have in the last few thousand years Unfortunately, or perhaps fortunately, there is no basis for prediction concerning their nature, whether for better or for worse. There is really no good reason for referring to the present as "a post-glacial epoch"; it may prove to be an interglacial epoch. But our ancestors weathered ice ages in the past, and presumably we are better equipped for such contingencies than they were Should the average annual temperature of the earth as a whole be reduced some-

thing like 10° F. and remain at that lower level for a few millennia, it is likely that once more the greater part of Canada, the northern United States and the Scandinavian countries would be buried beneath great ice sheets. But in consequence of the removal of water from the sea as vapor to form the snow to produce the glacial ice, considerable areas now shallowly submerged along the coastlines in middle and equatorial latitudes would emerge as dry land Indeed, it is likely that the area of land suitable for human abode would be nearly or quite as great at the climax of a glacial period as it is to-day.

By the same token, the disappearance of existing bodies of glacial ice as a result of rapid amelioration of climate in the not-distant future would, if it occurred, be a decidedly mixed blessing Return to the sea the water now imprisoned in the ice on the Arctic islands, Greenland and Antarctica, without any compensating changes in crustal elevation, and sea level would be raised 50 or 60 feet the world around Considering the number of people who now work or sleep in buildings in metropolitan communities not over 50 feet above sea level, the importance of such a change is readily apparent.

But from the geologist's point of view these are relatively trivial matters With due deference to the nature of the climatic variations and geologic changes which are certain to occur in the next few thousand years, there is nothing to be expected from such sources that would seriously deter the human species from maintaining a comfortable existence on the surface of the earth for an indefinitely long period of time—a period to be measured in millions rather than in mere thousands of years.

II

At last, it is generally understood that man is a part of nature. He may be something more than an animal (that depends largely upon definition), but he is none the less truly a part of the animal world. Like the other inhabitants of the earth, man is a product of evolutionary processes operating on this particular planet

We may be the latest product of the creative forces displaying themselves in the organic development taking place in this particular portion of the cosmos, but we have no reason to assume that we are the last achievement of those forces Nor does the fact that man has arisen from a lowly origin through processes of evolution validate the optimistic inference that he will necessarily continue his progress to ever higher levels of activity. Evolution does not guarantee progress; it merely guarantees change The change may be for the better or the worse, depending upon the conditions of time and place and the vitality of the individuals concerned

The pages of Mother Earth's diary reveal an amazing and thought-provoking record of the progress of living creatures throughout the long eras of earth history. Again and again, in the procession of the living, dynasties of animals or plants have arisen from a humble origin to a position of world supremacy, maintained for a comparatively brief period and then lost forever Some have disappeared entirely as their paths have led them off into blind alleys. Others have sunk to a low level and have continued a degenerate existence to the present day. A few have given rise to other and more efficient forms of life that superseded their predecessors as leaders in the procession Gradually we are discovering some of the reasons for success and failure along the path of life. Beyond question, man may profit from these experiences of the past, if he uses the intellectual and moral resources which are available for him.

From the point of view attained through knowledge of geologic life development, man has to-day a unique opportunity to gain continuing security for himself and his progeny on the face of

the earth, but whether or not he takes advantage of that opportunity is to be determined largely by himself. So far as we can tell, man is the first animal possessing the power to determine his own evolutionary destiny, but there is nothing in the record which guarantees that he will use that power wisely.

The animal species that in the past have been able to maintain their existence for more than two or three million years are relatively few in number Most of them were comparatively simple types belonging to the less highly organized branches or phyla of the animal kingdom Many were inhabitants of the sea where environmental conditions were remarkably stable throughout long periods of time Among placental mammals, the major subdivision of the vertebrates to which man belongs, there is no similar record of longevity. Except under extraordinary conditions of geographic isolation, no species of placental mammal has persisted more than two or three million years No matter how successful it may have been temporarily in multiplying and spreading over the face of the earth, each has become extinct in a geologically brief span of time. Perhaps a half million years might appropriately be taken as the average "life" of a species in this group of highly organized and notably complex creatures

But extinction does not necessarily mean failure, it has frequently indicated the acme of achievement For example, some of the now extinct three-toed horses and four-toed camels passed on "the torch of progress" to their descendants, the one-toed horses and two-toed camels, and thus gained long-continuing security for their kind

What, then, does the future hold for mankind? Genus *Homo* has already existed for three or four hundred thousand years; the species *Homo sapiens* has about fifty thousand years to its credit If the average applies, we may expect nearly or quite a half million years more of existence for our kind and then either *oblivion as we reach the end of a blind alley or progressive development into some type of descendant better adjusted than we to the total environmental factors of the time.*

III

But does the average apply? Must man exit from the scene through either of the doors, that which closed behind the dinosaurs and titanotheres or that which opened before the three-toed horses and notharctines?

Most creatures have gained security by specializing in adjustment of structure and habit to particular environmental conditions, whereas man is a specialist in adjustability of structures and habits to a variety of environments No other vertebrate can live as can he on Antarctic ice cap, in Amazonian jungle, beneath the surface of the sea, or high in the air

Furthermore, man is the world's foremost specialist in transforming environments to bring them within the range of his powers Far more efficient than the beaver or the mound-building ant, he drains the swamp, irrigates the desert, tunnels the mountain, bridges the river, digs the canal, conditions the air in home, factory and office

As a matter of fact, adjustability to environment is accomplished more by controlling surroundings than by modifying internal organs or essential functions of the body When we ascend with Major Stevens into the stratosphere, or dive with Dr Beebe 500 fathoms deep off Bermuda, or live with Admiral Byrd through the long night of Little America, we take along with us a sample of sea-level atmosphere and temperate climate which is our real environment in a situation otherwise unbearable Fur-lined parkas and tropical linen suits are but a medium for ensuring an immediate environment as nearly as possible like that of middle latitudes when living in polar or equatorial surroundings

But regardless of interpretation of

procedure, the result is clear. Man has placed himself in control of external conditions to an extent immeasurably greater than has any other creature He has practically "drawn the teeth" of environment

Although we know little of the details, it is certain that most of the creatures of the past who "have had their day and ceased to be" were forced into extinction by changes of one sort or another in their environment, changes which came with such relative speed that they were unable to make adjustment to them in time Man need have no fear on that score

IV

It is, however, immediately apparent that man's conquest of his surroundings has resulted from his clever use of things Unless there is a ceaseless flow of cotton, flax and wool, of coal, iron and petroleum, of copper, lead and tin, from ground to processing plant to consumer, he becomes a puny weakling It is because he uses certain resources provided by his environment that he is freed from slavery to his environment Are these resources adequate to keep him supplied with what he needs to maintain indefinitely the sort of existence to which he has accustomed himself?

There are two fundamental sources of the goods and the energy which man uses in the grim business of securing the sort of living which he apparently desires On the one hand there is the farm and the waterfall, on the other there is the mine and the quarry Things which grow in the field or forest, and power produced by falling water are in the category of annual income Now that scientific research has made available the limitless quantity of nitrogen in the air for use as fertilizer, the resources of the plant and animal kingdoms are renewable; we use them, but we need never use them up In startling contrast the resources of the mineral kingdom are non-renewable; they are in the category of accumulated capital Petroleum and coal, copper and iron, lead and vanadium, these and many other prerequisites of modern civilization have been accumulated by nature through hundreds of millions of years of geologic activity. Thanks to scientific research, man is exhausting that store of mineral wealth in a few hundred, or at most a few thousand, years That inescapable fact is at rock bottom one of the most fundamental causes of economic distress, of war between nations and of strife between classes

Fairly accurate estimates of the world stores of many non-renewable resources are now available Take petroleum as an illustration The known available reserves of petroleum beneath the surface of the United States total at present approximately 17 billion barrels [2] Experts differ in their guesses as to the quantity of petroleum that may be discovered in the future in areas that have not yet been adequately explored with the drill or in known fields by discovery of deeper reservoirs not yet reached by the deepest wells in those fields There are also many varying shades of optimism and pessimism concerning the possibility of increasing materially the percentage of recovery of the oil present in a reservoir rock when penetrated by drilling operations Estimates of the quantity to be added to our petroleum reserves from these two sources range from 7 or 8 billion barrels to 15 or 20 billion I would incline toward the larger figures, considering them as maxima that are extremely unlikely to be exceeded On that basis, the present store of available petroleum beneath the surface of the United States is 25 to 35 billion barrels That is only about thirty times the annual domestic consumption of petroleum in recent years The average annual production of petroleum in the United States during the five years from 1934 through 1938 was almost one

[2] *American Petroleum Institute Quarterly*, 9: 2, 7, 1939

billion, one hundred million barrels,[3] and the 1939 production exceeds one and a quarter billion barrels. At the present rate of withdrawal, the domestic stores of this essential raw material would, therefore, be exhausted in less than a third of a century.

Data are not nearly so precise for the majority of foreign countries as for the United States It is, however, fairly safe to conclude that the world stores of petroleum will last only something like 75 years at the present rate of withdrawal. With the possible exception of Mexico, no other country has been as successful as the United States in the attempt to exhaust its petroleum resources in the shortest possible period of time, but rapid progress toward that result is now being made in many regions.

Lest we become too pessimistic in response to such unwelcome figures, we should promptly note that substitutes for petroleum are already known Gasoline, fuel oil and lubricating oil can now be manufactured from coal and other rocks rich in carbon, by processes of hydrogenation and polymerization. These are expensive processes, and their products can not now compete with the products from petroleum even in countries far removed, both geographically and psychologically, from the more productive oil fields[4] They will, however, come into use more and more in the next few decades.

Enough bituminous and sub-bituminous coal is known to be available within the United States to meet the present annual demand for coal, plus enough to manufacture gasoline and fuel oil in sufficient quantity to meet current demands for at least two thousand years. In addition there is enough oil shale—a rock rich in carbon but containing little or no oil—to meet present needs for petroleum products for at least three or four thousand years.

Although petroleum affords an excellent illustration of the relation of non-renewable resources to the activities of man, it is by no means typical of the items comprising nature's accumulated capital For nearly all the important non-renewable resources, the known world stores are thousands of times as great as the annual world consumption instead of less than a hundred times But for the few which like petroleum are not known to be available in such vast quantities, the story is much the same Substitutes are already known, or potential sources of alternative supply are already at hand, in quantities adequate to meet our current needs for at least two or three thousand years There is, therefore, no prospect of the imminent exhaustion of any of the essential raw materials, so far as the world as a whole is concerned, provided our demands for them are not multiplied rapidly in the future

That, of course, raises another question Will the demand for non-renewable resources increase materially in the future and thus hasten their exhaustion? Recalling the fact that the human population of the earth has increased almost five-fold in number in the last three hundred years, we might well be fearful on that score The study of current population trends, however, makes it readily apparent that the next few hundred years will by no means duplicate that record of the past If present trends continue, the all-time maximum population of the United States will be attained about the year 1970 and will total little more than 150 million souls[5] Thereafter, except for possible influx of immigrants from other countries, no further increase in numbers is to be expected.

[3] Statistics from *Minerals Yearbook*, published annually by the United States Bureau of Mines

[4] K. C Heald, "Technology and the Mineral Industries," WPA National Research Project, Report E 1, pp. 27–31, 1937.

[5] Thompson and Whelpton, National Resources Committee, Population Statistics, Vol. 1, "National Data," p 9, 1937.

Accurate figures are available for only a few other countries, such as England, France and Germany, but there is a strong probability that the all-time maximum for the "white" races will be reached during the last third of the twentieth century and for the entire population of the earth before the end of the twenty-first century Although the human family has doubled its numbers since 1860, it is extremely unlikely that it will ever reach twice its present number of approximately 2 billion The pressure of demand for non-renewable resources will not, therefore, become acute because of the increase in population in the near future Mother Earth is a very wealthy benefactress, and our heritage of physical resources is far greater than ordinarily supposed

There is, however, another reason why current consumption of non-renewable resources can not be taken as the basis for computing the "life" of such stores of basic materials The demand for automobiles, telephones, radios, airplanes, zippers, is to-day very unevenly distributed. Only a small fraction of the human population uses such things in any large amount. Other peoples are beginning to demand them and will do so increasingly as they become acquainted with the "benefits of civilization " In a few decades, unless we return to savagery, the world demand for many non-renewable resources will be twice or thrice that of to-day.

Taking all these things into consideration, it would appear that world stores of needed natural resources are adequate to supply a basis for the comfortable existence of every human being who is likely to dwell anywhere on the face of the earth for something like a thousand years to come.

Even so, there may be found here an excuse for the policy of "grabbing while the grabbing is good," which motivates many individuals and nations at the present time. That excuse might, of course, be offset by the suggestion that there is no need to take thought for a morrow a thousand years hence, if we have any respect for the ingenuity of our remote offspring There is, however, another phase of current trends in human history that should not be overlooked in this connection.

One hundred years ago, something like 80 per cent of all the things man used had their source on farms, most of the energy used to do the work of the world came from the muscles of living beings and from falling water. To-day only about 30 per cent of the things man uses come from things that grow; most of the energy with which work is done comes from petroleum and coal. For a century or more, the policy has been to use relatively less of the annual income and more and more of the stored capital

Now comes the change. Automobile steering wheels are made from soybeans; piano keys from cottage cheese; innumerable articles fashioned of plastics are produced in part from corncobs and alfalfa, multitudinous metal and rubber substitutes are synthesized from various farm crops Energy is transmitted at high voltages for hundreds of miles from hydro-electric turbines. A considerable portion of the annual budget for research is being devoted to progress in the direction of using more of the renewable resources—man's annual income, and less of the non-renewable resources—nature's stored capital

What this new policy will mean is readily apparent With progress along such lines, the pressure for political control of metalliferous ore deposits, coal fields and oil pools is lessened. Much of the physical basis for international jealousy is removed. At last the intelligence of science may make it truly practical to beat our "swords into ploughshares, our spears into pruning hooks."

Again comes the insistent question from the pessimistic critic. Is there land enough? Is there sufficient fertile soil to provide adequate food and in addition the plant materials for the ever-

expanding chemical industries? And again we hear the same reply. Yes, there is enough and to spare J. D Bernal computes from apparently valid data that the cultivation of two billion acres of land by the methods now in vogue in Great Britain would provide an optimum food supply for the entire population of the earth "Two billion acres is less than half the present cultivated area of four billion, two hundred million acres, itself hardly 12 per cent. of the land surface of the earth "[6] And in this calculation no account is taken of the increased yields that may confidently be expected from the continuing research of agronomists, plant breeders and experts in animal husbandry, not to mention recent developments in the new science of the soil-less growth of plants Evidently, the predictions of Malthus notwithstanding, mankind need have no fear that increasing populations will place an impossible burden upon the available sources of food Human ingenuity, intelligent use of renewable resources, wise adjustment of structures and habits to environmental conditions, seem competent to dispel that dread shadow

But these optimistic conclusions concerning the relation of man to the nonrenewable and renewable resources essential for comfortable existence are based upon world statistics Obviously, they do not apply with equal force to the economy of individual nations No nation, not even the Soviet Union, Brazil or the United States of America, embraces within its political frontiers a sufficient variety of geologic structures to give it adequate supplies of all the various metalliferous ores necessary as raw materials for modern industrial operations The United States, for example, must import nickel, tin, antimony, chromium and platinum if American manufacturers are to use those metals in the fabrication of articles essential to what we are pleased to call the civilized way of life.[7] Likewise, no nation enjoys a sufficient variety of climatic conditions to permit all kinds of foodstuffs to be grown on its farms and fields or gathered from its forests, and to allow the growth of all the various plants contributing raw materials to industry. The United States, again the most significant example for us, is forced to import all the bananas, coffee, tea, camphor, coconuts, flax, jute, quinine, rubber and shellac consumed in this country, either from foreign countries or its own over-seas possessions [8] It is entirely possible that, within a few decades, substitutes of domestic origin may be available to take the place of many, or even all of such commodities or that plant breeders and agronomists may find a practical way of extending the geographical limits of some of the plants whose products are considered essential so that any nation occupying a large fraction of any continent may actually be self-sufficient But for the present and probably for a long time to come it is evident that every nation is dependent upon many other nations for the raw materials that it needs for its own industrial prosperity

Perhaps the most important fact concerning the life of man to-day is this fact of interdependence No nation, community or individual can gain any lasting measure of security without taking that fact into consideration The resources that man must utilize, if he wishes to escape the fate of his less intelligent relatives now known only by their fossil remains, are unevenly distributed and locally concentrated The techniques of discovering and utilizing them are now fairly well known, but satisfactory procedures for making them and their products available to all members of the human family are not close at hand.

The very solution of the physical problems which man encounters in his attempt to maintain his foothold upon the

[6] J D. Bernal, "The Social Function of Science," p 347, New York, 1939.

[7] Brooks Emeny, "The Strategy of Raw Materials," p. 26 and chart facing p. 29, New York, 1937.

[8] *Ibid*, pp 26–37.

earth brings him all the more forcefully into bruising contact with psychical and spiritual problems that must also be solved if he is to continue his existence on this planet The critical question for the twentieth century is · How can two or three billion human beings be satisfactorily organized for the wise use and equitable distribution of resources which are abundant enough for all but are unevenly scattered over the face of the earth? Clearly, the future of man depends upon finding and applying the correct answer to that specific but far-reaching question

Man is not only a specialist in the art of coordinated activity, but the trend toward organization is recognizable in the entire development of cosmic administration. Electrons, neutrons and protons are organized into atoms, atoms into molecules, molecules into compounds, some of the compounds prove to be cells, and these are organized to form individual plants and animals Latest of all in the history of creative evolution certain individuals have been organized into societies Transcending all that has gone before is the development of human society, obviously the most difficult, but at the same time potentially the most glorious organization yet attempted

Two antagonistic alternatives present themselves as possible bases for this organization The issue between the two has never before been so clearly drawn as it is to-day The social group, whether it be the family, the industrial or commercial company or the political unit, may be organized on the principle of regimentation, or it may be developed according to democratic principles Both methods are being tried under a variety of conditions, and each has something to be said in its favor But both can not be equally conducive to the continuing existence of mankind One or the other must be selected as the basis for the future security of man

If regimentation be the choice, then the great mass of humankind must be trained for obedience—blind, unquestioning, but superbly skilful obedience. The educator becomes the intellectual and spiritual counterpart of the drill-sergeant in the army. This is no menial task, nor is its objective a mean one Skill is a commodity of which there is never likely to be an oversupply On the other hand, if democracy be the choice, the great mass of humankind must be trained for wise, self-determined cooperation Precisely those qualities of mind and heart which have long been extolled in Christian doctrine must be developed to the fullest possible extent Not only skilfulness but also the ability to govern oneself, the eternal prerequisite for freedom, must be developed in each member of the group

In so far as physical existence is concerned, there would seem to be little or no choice between these alternatives. Perhaps, human nature being what it is to-day, the regimentation of society may temporarily be the more efficient method. But the full circle of organic law embraces more than mere existence From the continuity of the evolutionary process, there has emerged a creature who is aware of vivid values in life, that may be found beyond the goods necessary for comfortable existence Ideas and ideals are powerful determining factors in the world to-day, and amongst them the ideal of freedom for the individual in the midst of social restraint is the most vital and compelling of all. Though it baffle our scientific tools for measurement, it is none the less a reality

It is in the yearning for freedom, the love of beauty, the search for truth, the recognition of moral law and in the awareness of spiritual forces that human nature is distinguished from all other sorts of nature Man shares with other animals the need for satisfactory economics, for adequate food and shelter, for the goods essential to existence, but his needs transcend these physical factors because his nature differs from theirs Probably nine-tenths of all the words that have been used since the dawn of speech in reference to "human nature"

have referred to those elements in the nature of man which are shared with other animals rather than to those which are man's unique possession It would be far better to concentrate upon the latter and thus to distinguish human nature from animal nature.

Regimentation may be good for man as an animal, through that type of social organization his need for goods may be efficiently supplied. But regimentation is certainly not good for human nature as thus distinguished Experience verifies what wisdom foresees; regimentation stultifies the spirit, destroys personality, standardizes thought and action Worst of all, regimentation means stagnation of the creative process and, as we have seen, stagnation among the more complexly organized vertebrates has led inevitably to extinction If man attempts to live by bread alone, mankind commits collective suicide Apparently the best and perhaps the only chance for mankind to succeed in the quest for security is through progress in the art of living on a high spiritual plane rather than through exclusive attention to the science of existence on a purely physical level.

V

To put this same thought in more specific terms, it means that coordinated activity directed toward efficient organization of individuals must become cooperative activity directed toward the enrichment of personality within an efficiently organized society This requires both intelligence and good will.

Fortunately, these characteristics are uniquely developed in the species of placental mammal with which we are preeminently concerned Man is a specialist in the use of both The trend of the past five thousand years may well continue, despite numerous temporary setbacks, throughout the next few centuries at least.

It is sometimes suggested that because man has specialized in brains, brains may cause his downfall, just as presumably the overspecialization in external armament contributed to the downfall of certain herbivorous dinosaurs. That argument by analogy is, however, heavily punctuated with fallacies. There is as yet no evidence that mankind is weighted down with a superabundance of intelligence. On the contrary, it is failure to act intelligently that endangers individuals and groups in the midst of competition To see in advance the remote consequences of contemplated action is an ability that ought to be increasingly cultivated rather than scouted as a menace

There seems to be no good reason why a sound mind should not be accompanied by a sound body. If the number of psychopathic individuals is increasing in this high-speed, technologic age, it is a challenge to be met not by bemoaning the imminent collapse of civilization but by intelligent adjustment of habits and activities to the new demands of the new times

Once the commitment is made to the belief that the cooperative way of life offers the best chance for the future security of man as an inhabitant of the earth, the need is greater for intelligence to be used as a guide for good will, rather than for good will to be applied as a brake on any possible increase in intelligence

The roots of self-centered individualism may be traced backward for at least six hundred million years in the record of geologic life development, whereas our heritage of social consciousness dates from a time only about sixty million years ago when gregarious instincts became clearly evident among placental mammals. That trend is, however, especially apparent in the group from which mankind has stemmed.

Man is still in the stage of specific youth. His "golden age," if any, is in the future rather than in the past. Human nature is still sufficiently plastic and pliable to permit considerable change, notably in this important area of attitudes and relationships wherein the in-

crease of good will as a motive for action seems most likely to result in beneficial adjustments to the new factors in the environment

In thus seeking a satisfactory coordination of intelligence and good will, it becomes necessary for research scientists to give more thought than has been customary in the past to the social consequences of their work They share with statesmen, politicians, educators and all molders of public opinion the responsibility for determining the uses to which the new tools provided by scientific research are put. As scientists they should continue to seek truth regardless of its consequences and to increase human efficiency in every possible way, but as members of society, as individual representatives of a species seeking future security as inhabitants of the earth, they must also do their utmost to ensure wise use of knowledge and constructive application of energy

There is a real difference between the so-called "social sciences" and the "natural and physical sciences" that has an important bearing here It is not that there is anything "unnatural" about the social sciences Man is a part of nature, and the study of human society is just as truly "natural science" in the real sense of the term as any other study. The difference arises from the peculiar factors and particular functions pertaining to the cooperative way of life. Whereas the scientific use of things may be achieved through the efforts of a very small minority of the citizens, provided with adequate facilities for research, the scientific organization of society in a democracy can be achieved only when the majority of its citizens have the scientific attitude toward social problems and act in accordance with that attitude of mind. In other words, only a few physicists, chemists and technologists are required for the mastery of our physical environment, but for victory in the struggle with ourselves every man must be his own sociologist.

Although this places upon the forces of education a Herculean task, it is not nearly so impossible an assignment as at first glance it might appear to be. In the first place, the responsibility upon the individual citizen is rarely that of designing a new social structure or charting a new program for society Almost invariably it is his duty merely to select from many plans, programs or proposals the one that seems to him most likely to produce the most desirable results for all concerned In the second place, scientific habits of mind have already been developed to a greater extent than is ordinarily recognized The garage mechanic attacks the problem of a balky automobile in a truly scientific manner. The salesman uses psychology in planning his approach to a difficult prospect The housewife thinks scientifically when about to concoct a new dessert or redecorate the living room In most cases, it is only necessary to apply in the area of social relationships the same habits of mind that have been followed in the area of individual behavior.

VI

In conclusion, the outlook for the future of man as an inhabitant of the earth is far from pessimistic. If certain tendencies already developing are encouraged and certain resources already available are capitalized to the full, there is good reason to expect that mankind will maintain existence and even live happily for an indefinitely long period of time. The opportunity is his to demonstrate the intrinsic worth of biologic phenomena and thus to justify the vast expenditure of time and energy involved in organic evolution With greater emphasis upon the development of intelligence and good will, he may achieve that which the temporarily triumphant dynasties of the past have failed to achieve Thus the geologist may turn from the long perspective of geologic history to the enticing vista of the geologic future of earth and man with high hope and even with confident assurance.

THE ROLE OF CHANCE IN DISCOVERY[1]

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IN 1751 Horace Walpole, the English statesman and diplomatist, wrote a letter to his friend, Horace Mann, in which he proposed adding a new word to our vocabulary, "serendipity" The word has not had large usage It is not commonly found in dictionaries of the English language When I mentioned "serendipity" to one of my acquaintances and asked him if he knew the meaning, he suggested that it probably designated a mental state combining serenity and stupidity! He was mistaken

Walpole's proposal was based upon his reading of a fairy tale, entitled "The Three Princes of Serendip" Serendip, I may interject, was the ancient name of Ceylon "As their Highnesses traveled," so Walpole wrote, "they were always making discoveries, by *accident* or *sagacity*, of things they were not in quest of" When the word is mentioned in dictionaries, therefore, it is said to designate the happy faculty, or luck, of finding unforeseen evidence of one's ideas, or with surprise coming upon new objects or relations which were not being sought In the progress of man's adjustment to the world in which he lives there have been many instances of serendipity

Probably the most astounding instance of accidental discovery in history was the finding of the western hemisphere by Columbus He sailed away from Spain firm in the faith that thus he would learn a shorter route to the East Indies and, quite unexpectedly, he encountered a whole new world. It is noteworthy that he was not at first aware of the significance of what he had found Indeed, it has been said that he did not know where, in fact, he was going, nor where he was when he arrived, nor where he had been after he returned, but nevertheless he had had one of the most remarkable experiences of all time. The important matter is that he did realize that it was a remarkable experience and followed it by making other voyages and thereby extended his knowledge of what he had done and laid a course which others might follow Such consequences have been common when accident has been favorable to a seeker after new things and the adventure has been fruitful

In the records of scientific investigation there are many instances of this sort of happy use of good fortune Consider for a moment the source and the development of our acquaintance with electrical phenomena. It is reported that some frog legs were hanging by a copper wire suspended from an iron balustrade (note the two different metals, copper and iron) in the Galvani home in Bologna; they were seen to twitch when they swung in the wind and happened to touch the iron Whether the twitching was first noted by Luigi Galvani, the anatomist and physiologist, or by Lucia Galvani, his talented wife, is not clear Certainly the accidental occurrence was not neglected, for it was the beginning of a long series of researches by Galvani into the electrical manifestations of living tissues—researches which have preserved Galvani's name in the terms "galvanize" and "galvanism" And it also led to experiments by Volta on the production of electric currents by contact of two dissimilar metals, and thus to the invention of the electric battery—experiments so fundamentally important that Volta's name is retained in the daily use of "volt" and "voltage" in speaking of

[1] An address delivered at a meeting of the American Science Teachers Association, Columbus, Ohio, December 28, 1939.

electrical potential. Such was the origin of the telegraph and, indirectly, of the telephone, radio-broadcasting and the promise of practical television And such also was the origin of our knowledge of animal electricity which we now use to tell the condition of the heart muscle, because every heart beat sends forth an electrical wave in the body of each of us, a wave which has an altered form when the heart is injured; and the animal electricity which we are beginning to use to learn about conditions in the brain, because of the rhythmic electrical pulsations which delicate instruments, applied to the surface of the scalp, can reveal as typical activities of that wonderful organ in various conditions of rest and activity, health and disease.

Even in the growth of electrical science serendipity has played important roles It was by pure chance that the mysterious relation between electricity and magnetism was discovered. The Danish physicist, Oersted, at the end of a lecture happened to bring a wire, which was conducting a strong current, to a position above and parallel to a poised magnetic needle Previously, and by intent, he had held the wire perpendicularly above the needle, but nothing happened; now, however, when the wire was set horizontally along the needle's length, he was astonished to note that, without any visible connection, the needle swung around until it was almost at right angles to its former position. With quick insight he reversed the direction of the current in the wire and found that the needle then deviated in the opposite direction. Later, when clearly understanding the situation, Faraday proved not only that an electric current in a wire can move a magnet, but also that a moving magnet can cause a current to appear in a wire From these trifling and casual incidents has gradually evolved our vast modern electrical industry—its immense generators, its ingenious devices for distributing extensively over great areas the power which provides innumerable conveniences for human service—light in dark places, a cooling breeze on a summer day, heat for our morning toast, sparks in motor cylinders, the automatic management of complex machines, safety at sea, and what not else that is helpful in our daily lives When we consider the prodigious and intricate involvement of electricity in the affairs of mankind throughout the world, Galvani's frog legs may be regarded almost as important as the caravels of Columbus

In the biological sciences serendipity has been quite as fruitful as in the physical sciences May I call your attention to some instances The eminent French physiologist, Claude Bernard, had the idea that the impulses which pass along nerve fibers set up chemical changes which produce heat About the middle of the last century he measured the temperature of a rabbit's ear, and then severed the nerve which delivers impulses to that structure, expecting, of course, in accordance with his theory, that the ear, deprived of nerve impulses, would be cooler than its mate on the other side To his great surprise it was considerably warmer! Without knowing what he had done, he had disconnected the blood vessels of the ear from the nervous influences which normally hold them moderately contracted, and thereupon the warm blood from internal organs flushed through the enlarged vessels in a faster flow Thus by accident appeared the first intimation that the passage of blood into different parts of the body is under nervous government—the most significant advance in our knowledge of the circulation since Harvey's proof, more than 300 years ago, that the blood does, indeed, circulate

Another striking instance of accidental discovery has been described by the investigator himself, Charles Richet It was concerned with that peculiar sensitiveness toward certain things—such as white of egg, strawberries, ragweed pol-

len and numerous others—*anaphylaxis* or *allergy*. It commonly results from an initial exposure to the substance which later becomes poisonous. The phenomenon had been noted incidentally before Richet's time, but because it did not receive attention it was virtually unknown. In his charming little book, "Le Savant," he has told the story of how, quite unexpectedly, he happened upon the curious fact He was testing on a laboratory animal an extract of the tentacles of a sea anemone in order to learn the toxic dose. When animals which had readily survived that dose were given, after a lapse of some time, a much smaller dose (as little as one tenth the original), he was astounded to find that it was promptly fatal. Richet declares that at first he had great difficulty in believing that the result could be due to anything he had done. Indeed, he testifies that it was in spite of himself that he discovered induced sensitization—that he would never have dreamt that it was possible!

An accident may be the occasion for scientific advances because of the serious problem which it presents Let me cite a striking example. No one anticipated that the polishing of rice would be harmful. Yet removal of the covering from the kernels resulted in tens of thousands of victims of the disease, beri-beri, and in immeasurable sorrow and distress As Mathews has pointed out, however, the study of beri-beri, thus unwittingly induced, revealed not only the cause of that disease but started exploration in the whole realm of deficiency diseases as well, and drove investigators to the discovery of some of the most intimate secrets of cellular processes.

A quite recent instance of serendipity was the finding of vitamin K, lack of which deprives the blood of an essential element for its coagulation. Dam and his collaborators in Copenhagen were working on sterol metabolism in chicks They noted that the animals on the restricted diet often exhibited extensive internal hemorrhages, subcutaneous and intramuscular. When the diet was changed to seeds plus salts, the hemorrhages failed to occur By critical tests the disease was proved not to be due to lack of any previously known vitamin, but to lack of a specific antihemorrhagic agent, contained in hog liver fat, certain vegetables and in many cereals. This agent, vitamin K, is reported to be an important factor in surgery. Patients afflicted with obstructive jaundice can be relieved by an operation, but unfortunately in that condition their blood may clot very slowly and therefore they are in danger of disastrous bleeding This danger can now be readily obviated by feeding vitamin K (with bile salts), for it restores to an effective concentration the deficient element of the clotting process—a happy benefit to human beings coming from a chance observation on chicks

There are many other noteworthy instances of serendipity which I might detail to you; among them Nobel's invention of dynamite, Perkin's stumbling upon the coal-tar dyes and Pasteur's finding that a vegetable mold caused the watery solution which nurtured it to change the light rays as they passed through. Dynamite placed gigantic powers in the hands of man; the coal-tar dyes have fundamentally affected such varied activities as warfare, textile industries and medical diagnosis, and Pasteur's casual observation has developed into an immense range of chemical theory and research.

Three legends of accidental intimations which led to fresh insight will allow me to introduce the next point which I wish to emphasize—the importance of the prepared mind It is said that Archimedes had the idea of specific gravity suggested to him while noting by chance the buoyancy of his body in water. And we have all heard the tale that Isaac Newton was led to the concept of a universal law of gravitational force when he saw an apple fall from a tree as he lay

musing on the grass in an orchard. Of similar character is the report that the possibility of the steam engine came to the mind of James Watt when he beheld the periodic lifting of a tea-pot lid by the pressure of the water-vapor within the pot. Now, many a man floated in water before Archimedes, apples fell from trees as long ago as the Garden of Eden (exact date uncertain!), and the outrush of steam against resistance could have been noted since the invention of fire. In all three instances a long time passed before the significance of the event was perceived. Obviously, a chance discovery not only involves the phenomenon to be observed, but also the appreciative and intelligent observer.

It was in recognition of this fact that the wise and discerning dictum of Pasteur is displayed in prominent letters in the corridor of the students' dormitory of the Harvard Medical School—"Dans les champs de l'observation le hazard ne favorise que les esprits préparés." In the fields of observation chance favors only the minds which are prepared. That expression has important implications.

In the course of our human experience no one can tell what new circumstances may arise, nor can one predict the moment of their arrival. To-morrow opportunities may appear the seizure of which or the neglect of which may have long-lasting and fateful consequences. There is a tide in the affairs of all of us which "taken at its flood leads on to fortune"—and not taken may lead on to misfortune. In other words, the unexpected is continually happening in our lives, much as it happens in the realms of exploration and scientific research. Chance throws peculiar conditions in our way and, if we have alert and acute vision, we see their importance and use the opportunity which chance provides.

What are the prerequisites favorable for making greatest use of a novel occasion when it arrives?

First of all, if we are to benefit by such an occasion for securing fresh insight and enlarging our experiences in untried directions we must be well equipped with knowledge of the past. Only when we know what has already been done by others who have gone before us can we judge the present scene. The word "research" is commonly employed to indicate scientific investigation. Why is not the word "search" quite as exact? The "re" in "research" implies that the investigator studies carefully the methods and results of earlier investigators and *looks again* at the problems which they strove to solve, with the advantage now of possessing all accumulated previous knowledge, ready for the flashing of an illuminating idea. That is the method of discovery in its most elaborate development. We do not need to go to such lengths, however, in order to enjoy in a mild way the satisfaction of bringing to bear, in unanticipated circumstances, the stored memories of bygone events. A historical reference in speech or literature, or a name in a poem, is endowed with larger significance if we contribute to it rich associations from our own past. "In Xanadu did Kubla Khan a stately pleasure-dome decree" are lines which do not demand information in order to appreciate their musical beauty, but if one knows the story of Kubla Khan as the poet knew it, and is acquainted with oriental magnificence, the words take on an enlarged and special meaning. Furthermore, with the mind prepared there is always the favoring possibility of continuing enrichment as one grows older. One brings to the reading of history and literature, to the unpredictable incidents of travel, to the flashing moments of conversation, and to the varied adventures of the passing years a substantial basis on which can be gradually developed manifold interests and the happy relations of the individual to his fellows and to his surroundings.

In the life of every investigator who

has had much experience, occasions of happy chance are likely to be found. During the past four decades in my own labors instances of such good fortune have several times occurred. When a man has passed his sixtieth year, it is said, he may at last be permitted, without censure, to engage in reminiscence Perhaps you will be tolerant, therefore, if I recount to you an example of serendipity that fell to my lot. After all, an investigator is not taking undue credit to himself when he calls attention to the fact that results which he has obtained in his researches have depended on a fortuitous incident and not on his own intelligence and insight! Of course, the case which I shall cite is not to be compared with the great discoveries of Bernard, Richet and Pasteur, but it will illustrate equally well some of the conditions which prevail when chance plays a role in discovery.

About forty-three years ago, shortly after the x-rays were discovered, I was using the mysteriously penetrating light to look into animals in order to watch the little known processes of digestion The churning and mixing of the food was clearly visible Occasionally, however, my purposes were wholly checked because the motions came to a dead stop That was a great annoyance; it seemed very strange, and I was at a loss to account for it But in scientific investigations, as in daily living, obstacles may yield important values I soon noticed that the cessation of the digestive activities was associated with signs of anxiety or other emotional disturbance Could it be that I was seeing the harmful effects of worry on the organs which serve to make the food useful to the body? That proved to be true, for when I petted the animals reassuringly the churning waves promptly started again, and when excitement was induced the waves promptly stopped. There was an instance of serendipity—a discovery which I was "not in quest of," a disclosure which called for the application of "sagacity," to use Horace Walpole's expressions. It was the beginning of many years of research on the influence of fear and rage on bodily functions—research which ultimately led to insight into the agencies of our organism which maintain the stability of the extraordinarily unstable material of which we are composed and which give us freedom to live and carry on our various activities untrammeled by external heat or cold, by flight to high altitudes or by the internal changes produced by strenuous efforts in which we may engage. The observation of the effects of worry on digestion also resulted ultimately in a suggestive concept of the nature of emotional excitement, and, furthermore, in the demonstration of a chemical agent which acts as an intermediary between nerves and muscles when muscles are made to contract or relax

There is another implication in Pasteur's dictum that chance favors the mind that is prepared, that is the importance of avoiding rigid adherence to fixed ideas It is quite natural for the uninstructed intelligence to find a comfortable security and serenity in a set of conventional opinions which have been satisfactorily prearranged. The unusual is promptly dismissed because it is not wanted; it does not conform to the preconceived plan The possibility of adventures in ideas is unknown to such benighted persons We who live in a world which we recognize as not settled, stationary and finally immobilized, but as presenting all manner of possibilities of novel and unprecedented combinations and readjustments, must keep our minds open and recipient, ready for new views and fresh advances. We must not dismiss the unusual and the extraordinary aspects of experience as unworthy of attention, they may be the little beginnings of trails leading to great unexplored ranges of achievement. In a world organization which is in flux, in an anxious society groping its way possibly to new forms, shall we blind our eyes?

The great solutions may arrive unheralded, and unless we are prepared to weigh ideas on their merits and judge them fairly and critically we may not be participants in the momentous decisions, but, instead, worried and unhappy bystanders

Regard for learning of the past, tolerance and free discussion of novel suggestions and readiness for cautious experimenting when opportunity offers—these features are typical of the prepared mind They are typical, also, of the finest educational spirit Indeed, it may be questioned whether a teacher who does not cherish an unprejudiced respect for the truth as handed down by our forebears and who is not on the alert for new revelations in the continuously opening vistas of truth—it may be questioned whether a teacher, lacking these fundamental attributes of intellectual integrity, is likely, himself, to develop minds which look out upon the world with perspicacity and adaptable understanding A teacher is likely to create students in his own image Alert and thoughtful graduates will go forth from a school or college when alert and thoughtful teachers, encouraged and fostered in their labors, exert their influence within its portals

Here, I think, is a further implication of Pasteur's dictum that chance favors the prepared mind That is that a school or college, by inspiring students with the high ideals of the best educational tradition, can make them ready to take advantage of the fortunate events which, amid extremely difficult and complex situations, are sure to appear Not only in the physical and the biological sciences, from which I have drawn most of my illustrations, but to quite as great a degree in political, economic and social affairs, important and pressing problems call for solutions A better world for all of us will be ours when these problems are solved Many new discoveries are needed in order that these problems may be solved—discoveries of ways to achieve more perfect justice among men, a fairer distribution of the abundance which agriculture and industry can produce, assurance of conditions which will promote good health and effective medical care, freedom from the distress caused by great oscillations between financial booms and depressions, the reduction of crime and the number of criminals, the stabilization of family life, and the avoidance or rectification of numerous other social maladjustments These are not hopeless situations They can be largely remedied The discoveries which will yield deeper insight into the modes of resolving these difficult and often baffling problems are likely to be made by minds which have been disciplined in directions which we have already considered And when such minds confront the complexities involved in these extremely puzzling social and economic questions, they may be sure that quite unforeseen possibilities of securing answers will spring forth—chances of serendipity, for which they will be sagacious

NATURALISTS IN THE WILDS OF BRITISH COLUMBIA

III. THE SUMMER AND PREPARATIONS FOR OUR SECOND WINTER

By JOHN F AND THEODORA C. STANWELL-FLETCHER
DIMOCK, PENNSYLVANIA

FROM late May until the end of July, the open banks, meadows and woods were real flower gardens One charming color combination succeeded another Early in the season the open hillsides were red and yellow with columbines (*Aquilegia formosa*) and yellow daisies (*Arnica cordifolia* and *Arnica latifolia*) and white with saskatoon (*Amelanchier florida*) The dark floors of the spruce and pine forests were covered with carpets of white clintonia (*Clintonia uniflora*), bunchberry (*Cornus canadensis*) and beds of delicate pink twin flower (*Linnaea borealis var americana*). Then there were waves of blue and purple lupines (*Lupinus* sp) and Indian paintbrush (*Castilleja miniata* and *Castilleja angustifolia var Bradburyi*) in every shade of red, pink and orange The banks in front of our cabin were covered with wild roses (*Rosa acicularis*), the meadows and river banks with forget-me-nots (*Myosotis alpina*), blue-bells (*Mertensia paniculata*) and more masses of paint brush In July the green meadows became a sea of acres of blue larkspur (*Delphinium Brownii*) and monkshood (*Aconitum columbianum*) With the fresh green of the newly leafed-out poplars and willows, the dark green of the evergreens and the mountains still white with snow, the world was a gorgeous place

CHILCOTIN VARYING HARE

And in the midst of all this beauty came the mosquitoes, it was the last week of June No one who has been in the far north in summer-time needs a description of the insect life Although the flies and mosquitoes in the Driftwood River region were not nearly so bad as the ones we had experienced in the tundra and muskeg country, they made life miserable It was impossible to work outside without head nets, and the roar of mosquitoes in swampy places or thick woods completely drowned out the song of birds in near-by bushes and trees Our cabin windows and doors were well covered with wire screening, but the clouds of mosquitoes on the outside of the screens were so thick that swarms got into the cabin whenever a door was opened By the end of July the worst of the mosquitoes was over During August we had black-flies, but these were not nearly so bad as the mosquitoes In late August and September there were also swarms of yellow-jackets which devoured every particle of meat that was not tightly covered If we wanted a mammal skeleton cleaned for a museum speci-

men we had only to put it outside, and by nightfall it would be entirely free of meat and gristle.

The long days were very hot when the weather was clear Our thermometer often reached 88° or 92° F. in the shade and went up to 120° in the sun. The nights were short and cool, the temperature dropping 30° to 50° or more as soon as the sun went down in the northwest In May and June there were mornings when the water in our buckets had ice on it even when the temperature had been 90° in the daytime It was not really dark until 12 00 at night and we could see to read at 10 00 P M At 2 00 A M it began to get light again That country never did things by halves It spoke in superlatives The weather was never temperate and life was full of beautiful and miserable things, but in spite of many hardships the beauty always spoke to us most strongly.

The summer of 1938 was a very dry one—drier than any for some years, the Indians said It was hard to believe that a country flooded with water from the tons of melting snow could become so dry. In July and August forest fires became prevalent One especially bad one at the north end of Takla Lake began working up the Driftwood Valley One day, clouds of smoke were so dense that we could not see fifty yards across the lake Eyes smarted and breathing was difficult We had no means of knowing whether the fire was four or forty miles away, but we did know that if it reached the dry pine ridges a few miles south of us there would be no hope of saving our cabin, so we promptly prepared to vacate We made a log raft on which we could put our valuables and food, and had everything packed in duffle-bags and boxes ready to roll into the lake at a moment's notice If the fire came, our only hope was out on the water, but even then, chances of surviving were small,

WEASEL DRAWN FROM LIFE BY AUTHOR

YOUNG COYOTE CAUGHT ALONG DRIFTWOOD RIVER SEPTEMBER, 1938

for fires in that country were known to jump from one lake shore to the opposite shore a mile away, and our lake was only about five hundred yards wide Hot, acrid smoke from a forest fire will suffocate a person quickly, and our lake was too cold to allow one to stay in its icy depths for more than a few moments There was no sense in traveling north and leaving the cabin and our lake, for we might have been caught in the forests before reaching any large body of water By nightfall there were still no signs of fire in our immediate neighborhood though the smoke was denser than ever But in the early morning, at about 4 00 A M, a light drizzle of rain began, later turning into a real rain after a few hours The smoke gradually cleared away We learned some weeks afterward that the fire was actually twenty-five miles from our lake It took us nearly two days to move all our gear back into the cabin again and to straighten it out once more.

Early in August we bought a pack-dog from a white man at Takla His name was "Wahoo" and he was a huge fellow weighing seventy-five to eighty pounds Capable of carrying fifty pounds, he usually packed thirty-five pounds for us, and with Rex carrying fifteen to twenty-five pounds, longer trips were made possible Wahoo had been chained up for months, and he greatly appreciated the freedom he had with us, as well as the companionship of Rex Both dogs loved to work—as all dogs do; they went with us everywhere, and were a wonderful help, even though we were kept busy feeding them Fresh meat would not keep at this season and we were obliged to fish hard for long hours nearly every day to keep ourselves and the dogs in meat

During August we camped for a few weeks at the bottom end of Bear Lake One night when two of Charlie's sons were camped near-by, we had a curious visitor At bed-time we all heard a

A LARGE BUCK CARIBOU, OMINECA MOUNTAINS

strange cry from the woods, and a few hours later the dogs suddenly made a great racket The Indians came over from their camp to tell us about a queer creature which they had distinguished dimly in the light of the dying fire embers It was very large, they said, and "go soft just like a man on his hands and knees" When their trained hunting dogs had been let loose, they would not chase this animal in the usual eager manner, and the Indians, ever alert for the uncanny and supernatural, were scared They built up their fire and remained awake the rest of the night. Judging by this description and the cry we had heard, we decided that it was a cougar (*Felis concolor*) Although cougars were frequently seen and killed in the Hazelton district and there were reports of one or two at Takla Lake, they had not reached the Bear Lake country and were unknown to the Indians there

The next morning a black bear (*Euarctos americanus*) walked by along the edge of the lake, and when we reached home we found that apparently another bear had torn down a meat box from the rear wall of the cabin, removed the hinges with a light pat, and gone off with our last ham and four pounds of cheese A black bear-cub skin, that had been tacked to the wall to dry, was found fifty yards away

A week later, when one of us was going through the woods in search of warblers, he came upon a grizzly bear (*Ursus sp*) eating berries Man and bear were 100 feet apart and each saw the other at the same time The bear went on feeding and ignored the intruder, who stood still and looked for a climbable tree, having no rifle other than a 410 bird gun After a few moments the bear gave an irritated snort and moved off into the undergrowth

This section of British Columbia was supposed to be great grizzly-bear country The bears, both black and grizzly, were most often seen on the open moun-

tain sides at timber line or above, where they holed up for the winter In late April or May they came out and, when the fish began to run in the lakes and rivers, came down to fish In August and September they also gorged themselves on berries Large numbers of poplars all around our cabin were covered with bear-claw marks and other signs On our pack trip from Hazelton in August, 1937, there was such a strong scent of bears—like bad cabbage—in all the thickets, that we often had difficulty in persuading our horses to pass through Everywhere we heard hair-raising tales of grizzlies attacking and mauling human beings, but in each case it turned out that the bears had been first interfered with by man, usually wounded, or their young placed in danger

Late in August an unaccountable odor from the river caused us to make an investigation We found the water choked with hundreds and thousands of scarlet spawning Kokanee (*Oncorhynchus nerka kennerlyi*). This dwarfed relative of the blueback salmon averaged eight inches in length, and apparently came up the Driftwood River from Takla Lake at the same time every year, according to reports from the Indians in that vicinity The river teemed and reeked as the small fish made their way steadily upstream Thousands of the dead and decaying Kokanee lined the gravel bars and banks, while countless numbers struggled feebly in the shallows When the salmon first appeared, the river water was clear, and their red-gold bodies and bright green heads, glittering where the sunlight struck them, were an amazing sight The trout gorged themselves on the small salmon and would not show interest in any other lure Then the river was putrid with the dying fish as they lost their brilliant coloring and became scarred and ragged

CAMP ON OMINECA MOUNTAINS AUGUST, 1939

Tracks along the river banks indicated that almost all the animals in the country were enjoying a fish diet, and one day

we caught a young coyote (*Canis latrans incolatus*) pup alive. She did not appear to be vicious, and sat in the canoe between our legs as we paddled home. She had not yet cut all her teeth and was a beautiful little thing with huge prick ears and golden eyes that matched the tan and gray of her fur We made a cage for her and fed her with milk and cooked fish, which she took readily from a spoon but never directly from the hand After a few days, the weather cleared sufficiently for us to take a series of photographs We held the little pup in our arms and fondled her and she only occasionally tried to bite On the fourth day we let her go free She went off a short distance and apparently spent the night half a mile away from the cabin

When nature's scavengers had cleared the river banks of the dead Kokanee, and the river was its natural, clear self again, the trout were ravenous indeed They were fat and full of fight, the mere suggestion of a spoon or spinner was immediately pounced upon and borne away into the depths below some rock or submerged log where the handling of a twelve-pound fighting trout was hazardous and fraught with difficulty Previously, these same trout had been comparatively sluggish, but there was no doubt of their fighting capacity by September

It was in September that we discovered in the stomachs of some of the trout three tawny lemmings (*Lemmus helvolus*) Two were in perfectly good condition, and one was partly digested Later we found the remains of or saw the live animals in six different types of habitat in the Driftwood Valley. sphagnum bog, deep spruce and pine forest, the river bank, a rock pile, on the mountain sides and on the shores of Bear Lake Judging from this and the fact that we had seen no signs of these lemmings before, we decided that there must be a sudden influx of them. The Indians reported that they had always found

PACK HORSES GRAZING ON MOUNTAIN MEADOW AUGUST, 1939

them only on the sides or summits of mountains in previous years With the help of our dogs, we caught four in our hands and discovered that they were capable of screaming loudly and shockingly We also caught five of them in unbaited traps set in runways At that time these lemmings were considered rare and much desired by the museum. They have since been reported as reaching plague proportions in two localities in British Columbia

The gold of the poplars was like sunshine everywhere And there was that silence which presaged the long winter ahead

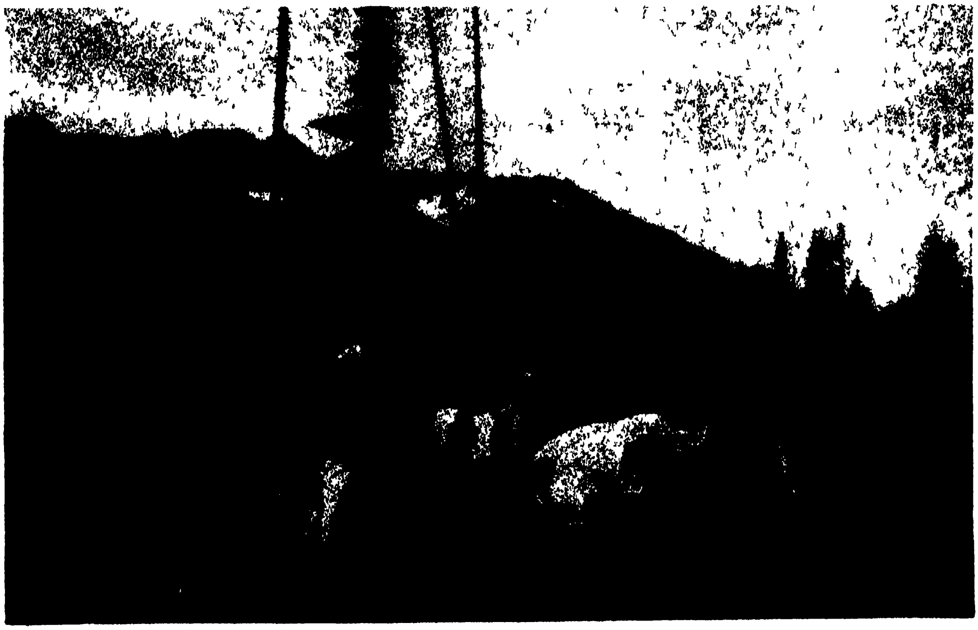
We made a trip to the top of the Driftwood Mountains, with the dogs carrying packs and thus permitting us to take enough food for some days For a few miles we followed a wide trail, partly overgrown, which had been made by Indians to enable them to drag a large dug-out canoe, made from a balsam poplar (*Populus balsamifera*) at the foot of

BEAR LAKE INDIANS WITH SKINS OF BLACK BEAR CUBS MAY, 1938

In early October, during one week, we took from the same trap set in a wide mouse runway in a sphagnum bog one tawny lemming, one lemming mouse (*Synaptomys borealis dalli*), one British Columbia red-backed mouse (*Clethrionomys gapperi saturatus*), one meadow mouse (*Microtus pennsylvanicus drummondi*) and one Boreal white-footed mouse (*Peromyscus maniculatus borealis*)

Once again the fall coloring of the woods came to gladden our surroundings

the mountain, to the Driftwood River The first part of the actual climb was through a tangle of that miserable devil's-club (*Fatsia horrida*) which retarded progress considerably For many hours it was necessary to cut our way through the prickly masses reaching above our heads The first night we spent by the edge of a rushing mountain torrent in almost impenetrable forest growth By noon the next day we reached a level open place, high up, where a stream trickled by a few sparse, stunted



PACK HORSES ON HAZELTON-BABINE TRAIL AUGUST, 1937

IN GROVE NEAR CABIN POPLARS SHOWING BEAR MARKS
NOVEMBER, 1937

MRS FLETCHER WITH REX AND WAHOO IN FRONT OF CABIN
DECEMBER, 1938

spruces Here we strung up a light fly-tent and made camp Behind and above us the mountain rose almost a thousand feet, before, and six thousand feet below us, was a grand view of the entire Driftwood Valley where our little lake gleamed in the sunlight in company with hundreds of others of whose existence we had been unaware The mountains above our camp were precipitous on the east and steeply rolling to the west There were miles of upland meadows, yellow where the burning mountain sun had scorched them, and green and full of autumn flowers in the hollows where there were springs or patches of old snow From these beautiful uplands we had panoramic views of great mountain ranges and valleys from the south to the northwest On the map this area was indicated by a blank space marked "Unsurveyed" These snow and glacier-covered mountains appeared to be higher, by thousands of feet, than any of the mountains we had seen previously in the country surrounding the Driftwood Valley and Bear Lake districts Far below to the northwest we could see the spot where the Driftwood River began its winding journey to Takla Lake

Off toward the south and to the northeast we saw two huge clouds reaching high into the heavens They were pink below and blossomed out, as they rose higher, into lovely balls of purest white But they were smoke clouds from huge forest fires, hundreds of miles away, where birds and mammals were suffering torture and death because of man's carelessness or greed

While there was much evidence of recent animal life in the shape of deer, bear and goat tracks on the mountain tops, we saw and heard only two marmots (*Marmota caligata oxytona*), a few Townsend's solitaires (*Myadestes townsendi*), and some ptarmigan, probably the rock ptarmigan (*Lagopus rupestris*), which flew away over the jagged precipitous mountain side The bears were

MR FLETCHER WITH DOGS CARRYING PACKS DECEMBER, 1938

obviously in the lowlands "berry picking" and most of the summer birds had departed

When we reached home again we made preparations for the coming winter The cabin walls were carefully rechinked with moss, for the old chinking was dry and shrunken and would let in cold winter air Wahoo hauled a sled carrying earth which was piled around the outside walls of the cabin, and he helped us considerably with the woodpile, which was stacked higher and higher This time we were well prepared for winter

Our library was rather small and by the end of November, 1938, we had read everything at least three times over Magazines were digested from cover to cover, including the advertisements In this way we read much on subjects in which we were not especially interested, and decided that we obtained a much broader knowledge than we did from the wealth of reading material which one has barely time to skim through at home in the rush and hurry of the so-called civilized life Our calendars were being marked off with alarming rapidity, and we reluctantly thought of our nearing departure in December from this land which was ever more delightful and interesting and which we had come to look upon as home At night, when we stood outside our cabin to watch the low-hung stars, we had still that never-lost thrill of isolation and sense of aloneness The light from the cabin windows was a feeble object in the vastness of the wilds around us But in that cabin were contained all the things that made life possible

In early November we made a brief trip to Bear Lake, where we met the pilot of the airplane which carried the trader's freight Arrangements were made for him to pick us up on December 31st, or "as soon thereafter as weather permitted," from a lake thirteen miles from Tetana, as our lake was too small and the ice too unreliable for safe landing He was to take us and the dogs down to

MR FLETCHER WITH DOGS ON UNNAMED LAKE
NORTH OF LAKE TETANA DECEMBER, 1938

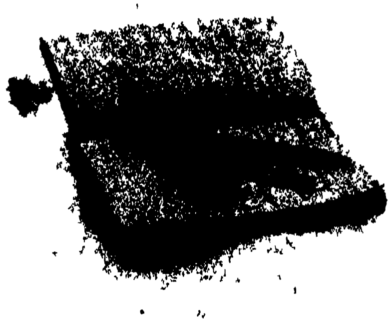
LOOKING OVER DRIFTWOOD VALLEY SEPTEMBER, 1938

Fort St James on Stuart Lake, where we would start our first journey into the outside world

On our return trip to Tetana it snowed considerably, and after that the temperatures were a little lower each day The golden-eyes, three of them, were still with us, and our friendly dippers appeared once more, cheerily singing and chasing each other Bear Lake Charlie came to us for treatment of a severe axe-cut in his leg, and we obtained three otter skulls (*Lutra canadensis evexa*) from one of Charlie's sons only after considerable persuasion The boy would not sell these skulls and he wanted to be sure that no dire results would follow his parting with them He was afraid that his mother would be possessed by the spirits of the three departed otters and eventually become insane

Snow came, and more snow The "flour-sifter" was working in earnest The animal tracks became scarce, and finally Christmas came once more Just as during the early part of the previous winter, there were no signs of the wolves, and moose were scarce and we were unable to obtain any fresh meat. We lived on canned foods more than we liked One of us reached the stage, by Christmas, where she was dreaming of "sausages bursting from their jackets" On Christmas Day we had a splurge of foods For breakfast we ate oranges, bran-flakes, scrambled eggs (made from egg powder) and bacon, with toast and coffee It was a bright day, 44° below zero Fahrenheit, and the dogs shook their feet and danced after a few minutes in the biting air We read, played solitaire and parcheesi, and in the afternoon indulged in a delicious egg-nog, using the last two eggs which had been saved up for that express purpose These were fresh eggs which were dipped in a preserving fluid and we occasionally got crates of them and kept them successfully for months For supper we had tomato juice, clam chowder, corned beef and vegetables fol-

LOOKING DOWN ON DRIFTWOOD VALLEY SEPTEMBER, 1938



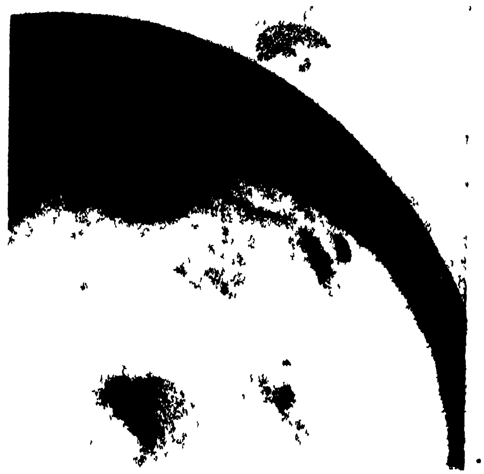
MASKED SHREW
FOUND FROZEN IN LIFE LIKE POSITION
DECEMBER, 1937

lowed by peaches and whipped evaporated cream, at eight o'clock we retired to bed

Throughout the entire year and a half which we spent in the Lake Tetana region our health had been perfect Never a sign of a cold or the usual germs that keep one half alive during most of the seasons in the civilized world Our only bodily ailments were occasional mild cuts and muscular exhaustion As far as we knew, the health of the Bear Lake Indians was also excellent unless they went out to the nearest post, where they got colds, flu, measles or whatever was prevalent Our comprehensive supply of medical stores was practically untouched except for the few mild drugs we occasionally gave the Indians

SKINS OF TAWNY LEMMING
TAKEN NEAR LAKE TETANA OCTOBER, 1938
PHOTO BY IAN MCTAGGART COWAN

Before noon on December 29th, we said good-bye to our cabin and lake with much feeling, and promised them to return as soon as possible In the afternoon we reached the lake where the plane was to pick us up We were followed by the Indian boys who, with dogs and toboggan, were bringing the six to seven hundred pounds of duffle, specimens, etc, from the cabin We made camp under the shelter of a huge spruce tree On December 30th, the Indians went back to Bear Lake and we spent the day tramping a trail on the lake for the skis of the plane to land on During the night the weather turned suddenly milder, snow came, and by morning a blizzard was sweeping over the land With little success we tried to keep the double track on the lake packed down The snow-storm lasted on and off for four days, during which time the temperature rose steadily and the weight of snow on the lake, coupled with the warm weather, caused "flooding" in places where water was seeping through cracks underneath the snow Approximately four feet of snow fell during the storm, on top of the three feet already on the level ground Dry firewood became more



RED BACKED MOUSE NOVEMBER, 1938

and more difficult to find and carry; the trail on the lake had to be kept packed down and worst of all our reserve food supply was almost gone But we were confident that the plane pilot, whom we knew to be a person of resource and wisdom, would find us at the first possible opportunity Travel was almost impossible over the fresh damp snow into which we sank even on snow-shoes It took two hours to make one trip up and down the mile-long track on the lake

On the evening of January 3rd, the snow lessened and the moon appeared, it was almost full and we went out to the lake and packed the trail down for hours The next morning was cold and clear and our trail was hardening But we suspected that the plane if it came that day would stick in the slush below the snow At noon, while we were resting from our exercises on the lake, we heard a droning, and soon the plane was circling about picking up our location, which we had marked with a huge cross of spruce branches A few moments later we were hurrying along the trail where it had landed and stuck in the overflow As we feared, our trail had not yet hardened sufficiently The pilot greeted us with a grin and apologized for the storm which had held him back, then, with the co-pilot and the mechanic helping, we cut trees from the shores of the lake and jacked up the plane When it was clear and taxied down to our pile of baggage, it stopped with a lurch and was stuck once more. This time was worse than before, and meant hours of labor before the plane could be freed. The afternoon was passing and so we were obliged to clear the broad skis and wait for the next morning The men, on learning that we were down to our last can of beans and a few pilot biscuits, brought out their emergency rations They had freshly-baked bread, meat and vegetables, and various kinds of canned foods which looked marvelous to us after several days of very scanty rations They had ideas of heavenly dishes such as fried potatoes and onions Unfortunately, we were obliged to demonstrate that when cooking outside under such conditions (the temperature was then 15° below zero Fahrenheit) over our huge fire, only the simplest canned things were practical The pots of food had to be held over the fire which had sunk down several feet below our level and whose wet logs shot up clouds of smoke

BOREAL WHITE FOOTED MOUSE

Moreover, it was necessary for every one to dip out of the pots, for, if the food was put on plates and passed around, it froze hard before it was eaten We wept in the smoke, blistered from heat in front and froze behind while we took turns at the pots and dried wet socks and moccasins One of the men muttered that the next time his wife back in town complained of washing dishes he could tell her a thing or two

The airmen set up their small wireless set in a snowdrift close to the fire and worked patiently for hours with stiff and frozen fingers until they had managed to broadcast a message to headquarters saying they had found us O.K. and could not get back that night, but hoped to make it the next day We in our turn were amused at the ways of the civilized world to which we were returning We had been completely out of touch with the outside for months at a time with no one knowing whether we were alive or dead, and it had seemed quite unimportant

Our dogs, utterly unused to people

other than ourselves and a few odd Indians, were astonished at the sudden coming of these strangers and the constant conversation and noise, as we sat by the fire below the spruce tree. After the airmen had burned a few holes in mittens, socks and moccasins from too sudden drying, they went to bed. Each had a warm sleeping robe, and after digging out a hole in the snow on the other side of the tree from us, using snow-shoes as shovels, they had gathered spruce branches on top of which they put a large grizzly-bear skin, one of our specimens, and the engine cover from the plane.

During the night the temperature dropped to 35° below zero Fahrenheit, and in the early morning we found that our trail on the lake was solid and smooth. The oil from the engine, which had been removed the previous evening, was heated and poured in the engine, two huge blow-lamps underneath the tarpaulin cover warmed the machinery, and our gear was loaded into the plane. After several hours, while the plane skis were chopped free from the ice into which they had frozen fast during the night, the engine roared and a few moments later we were climbing up over the lake, circling toward the south, and in a few minutes had passed over our little cabin at Tetana. It looked tiny, like a doll's house engulfed in a land of endless mountains and forests, but we had in our minds a very clear picture of it which would never cease to call us back, from the worries and hurries of the cities, to the fresh clear air and the wild-life of the woods.

TWENTY-FIVE YEARS' QUEST OF THE WHALE SHARK

ITS CONSUMMATION IN THE MOUNTED SPECIMEN IN THE AMERICAN MUSEUM OF NATURAL HISTORY

By Dr E. W. GUDGER

HONORARY ASSOCIATE IN ICHTHYOLOGY, AMERICAN MUSEUM OF NATURAL HISTORY

When Alexander had brought under his sway the whole known world of his day, he is said to have fallen into a profound melancholy because there were no more worlds for him to conquer Not so the scientist As he climbs the mountain of knowledge his horizon expands and he realizes how much more there is to be learned In this article is given in brief form some idea of long years of study of one fish, ending in the putting on exhibit of the most beautiful mount of it in the world But, to the student it is clear that all investigators of the whale shark together have just scratched the surface What exact knowledge do we have of its anatomy (of its curious gill-arch apparatus, for instance), of its food, of its habits and especially of its method of reproduction?

But let us take note of some things that have been learned since the fish was first described in 1828, and particularly of some of the things that the present writer has learned in his 25 years' pursuit of the whale shark And then it may interest the reader to learn something of the various and long-drawn-out stages of painstaking work by which the crude skin of our whale shark has been transformed into the magnificent mounted fish now on display

The whale shark (*Rhineodon typus*), portrayed in Fig 1, is the largest shark that swims the seven seas to-day It has been measured up to a full 45 feet and estimated up to 60 by a scientific man, and up to 70 feet by whale fishers accustomed to appraise the length of the leviathans of the deep The whale shark, like the sperm whale, is especially large forward, having the biggest head and largest mouth of any living animal save some of the largest whales In the mouth cavity of an average-sized specimen (say 30 feet long) an average-sized man can crouch, as Fig 2 shows

Another living shark, *Cetorhinus,* the basking shark, may attain to the length of *Rhineodon,* but it does not have the bulk The basking shark is comparatively slender and has a small head ending in a pointed bullet-shaped snout with the normal-sized mouth underneath in the normal shark position On the contrary, the enormous head of the whale shark continues forward and ends bluntly in the wide terminal mouth However, both these huge sharks were far exceeded in size by the extinct shark, *Carcharodon* We are ignorant of its form and outline, but since it left great triangular fossil teeth, 6 inches long, it is well named *megalodon*—huge-toothed In length it probably reached 80 to 100 feet This giant was the great-great-grandfather of the *Carcharodon* of to-day, the true man-eater

All sharks, and particularly large ones, are, by the general public, automatically put down as man-eaters And that is the first question asked by those who for the first time see the mounted whale shark But for all its size, this giant of the seas is entirely harmless Even when attacked by its one enemy—man—it offers no retaliatory violence, but merely seeks to escape by swimming or by diving But

Photograph by courtesy of Mr Charles T Wilson

FIG 1 WHALE SHARK ON BEACH ACAPULCO, SOUTHWEST COAST OF MEXICO
THIS IS THE FISH WHOSE MOUNTED SKIN IS NOW ON DISPLAY IN THE HALL OF FISHES IN THE AMERICAN MUSEUM OF NATURAL HISTORY

should a 30-foot specimen thresh out with its great tail-fin in 15-foot swings and strike a rowboat, it would surely reduce this to fragments As a matter of fact a 30-foot whale shark is infinitely less vindictive and dangerous than a 30-inch vicious common dogfish

Although at Acapulco, southwest coast of Mexico, whence our skin came, the whale shark is called "tigre del Mar"—the tiger of the sea—this is because its yellowish-white vertical stripes and spots resemble those of a tiger (Fig 1), and *not* because of its disposition The Cubans call it "pez dama," which may be translated as "checker-board fish" in allusion to the curious squares on its skin, each with a spot in it But since the fish in Cuban waters is, as everywhere else, entirely harmless, the Cubans, with a better appreciation of its habits, give the words "pez dama" another significance—the "gentle fish " As a matter of fact *Rhineodon* is the mildest-mannered shark that swims the ocean

Large sharks require much food, and, fossil or recent, they invariably have large teeth to cut or rend large prey The exceptions to this rule are *Rhineodon*, the whale shark, and *Cetorhinus*, the basking shark Both have very small teeth set in bands, and both feed on very small animals In the whale shark, the backwardly hooked teeth are arranged in close-set rows to make a band reaching from corner to corner of the mouth. Such a tooth-band is represented in Fig 3 The teeth of such a band number about 3,000 in each jaw, but each tooth is only about one eighth of an inch long, as Fig 4 shows in natural size If one were to put one's hand on the tooth band of *Rhineodon*, this would feel like a coarse file—hence the derivation of the fish's name, *Rhineodon*, Greek *rhine* = file, and *odous* (*odon*) = tooth, the file-toothed fish

These small teeth indicate the kind of food on which *Rhineodon* feeds—small things, since it could not cut nor tear large objects Not only is it a whale in size but in manner of feeding, for it must subsist on small fishes, squids, swimming crabs, jellyfishes and especially on the multitudinous very small things that float or swim at the surface of the water—things that the scientist calls plankton To supply the energy to keep it—a huge engine—going, the whale shark must take

in vast amounts of these small objects This it is believed to do by swimming along with its mammoth cave of a mouth open. Into this go food and water The water passes through its curious sieve-like gill-strainers and out through the five gill-openings on each side of its head; the food is retained and swallowed

The whale shark was discovered, dissected and briefly described 112 years ago (1828) by Dr Andrew Smith, surgeon of the British troops at Cape Town, South Africa In 1849, he published the full account of his findings, and among other things he says that "the inner extremity of each branchial canal is obstructed by a sieve-like apparatus fringed with a delicate membrane offering an obstruction to the passage of anything but fluid" This description fell on my ears, deaf until four and one half years ago when I examined the gill-apparatus of the whale shark which was captured on the Long Island coast in August, 1935 Now it is clear to me that this gill-apparatus will catch everything but the most microscopic plants and animals Also it is understandable why the whale shark has such a cavernous mouth-cavity. It must take in hogsheads of water to get the pints of the minute plants and animals on which it feeds This plankton passes down a gullet having a caliber of about four inches

Its great cave of a mouth to the contrary notwithstanding, the whale shark is not the fish that swallowed Jonah

After C H Townsend, 1913

FIG 2 MOUTH OF A WHALE SHARK

THIRTY EIGHT FEET LONG IN THE CAVERNOUS MOUTH OF AN ADULT WHALE SHARK A GROWN MAN MAY CROUCH WITH ROOM TO SPARE.

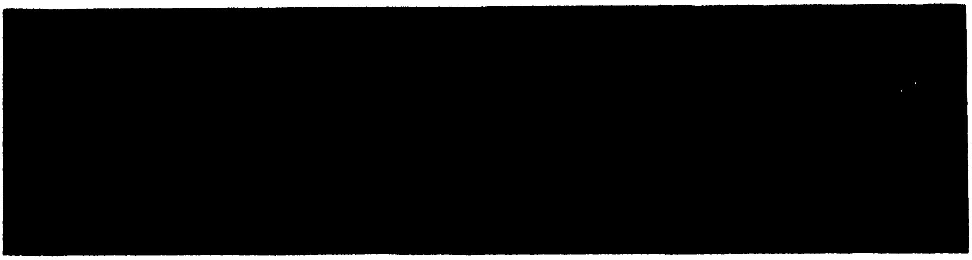
Early in June, 1912, I went by rail to Key West, Florida, on my way to study sharks and other fishes at the Marine Laboratory of the Carnegie Institution of Washington on Loggerhead Key, Dry Tortugas, the last far-flung outlier of the Great Florida Reef

As my over-seas train sped across Knight's Key in the darkness, little did I know that here two days before there had been captured a giant sea animal concerning which it was written in the stars that I had been "sentenced" to study it for the "balance of my natural life"—at any rate at this writing for over a quarter of a century

The next mail, following that which came down to Tortugas with me, brought Miami papers These were filled with adjectival descriptions of a great "sea monster" taken at Knight's Key two weeks before Since some descriptions called it a whale and since all agreed on its great size and its white spots, I (having no more knowledge of the whale shark than a child) put it down as one of the smaller whales, called, because of its voracious habits, the killer whale, *Orca gladiator*. But I was presently to realize my error

Late in the following July on my return north, I came by boat from Key West to Miami, through the Hawk Channel inside the Florida Reef, passing en route Knight's Key, henceforward to be remembered in whale shark annals At Miami I hunted up Captain Charles Thompson, the harpooner of the "monster" and the possessor of the skin He showed me this hanging over a long wooden support under a shed built to receive it on the bank of the Miami River

This huge skin, 38 feet long and 18 feet wide (if spread out flat), was the most enormous sea thing that I had or have ever seen. That I was tremendously excited goes without saying The skin had been cut and torn by harpoons and bullets and much maltreated by the skinners, but for all that, it was a wonderful thing to behold The fact that the animal had a cartilaginous skeleton and open gill-slits showed it to be a shark, but its great size and the large pale white spots, which everywhere covered the skin save in the ventral region, led to the apparently unanswerable question—"What shark is this?" The question was worth answering It *had* to be answered



After B A Bean, 1905

FIG 3 TOOTH BAND FROM THE UPPER JAW OF A RHINEODON 18 FEET LONG. THIS CAME FROM THE FIRST WHALE SHARK EVER RECORDED FROM THE WESTERN ATLANTIC OCEAN—ORMOND, FLORIDA, 1902

In the back of my head was a very strong recollection in a weak memory that somewhere I had seen the picture of a gigantic spotted shark living in the Indian Ocean On the long journey to my home in western North Carolina, it finally came to me that this figure was in a book on zoology which I had studied in college many years before At home, I found the book, "Elements of Zoology" by C F and J B Holder, and in it the picture. I then identified the great shark and wrote to Captain Thompson that it was *Rhineodon,* the whale shark.

Dr. C H. Townsend (director of the New York Aquarium) had published some preliminary notes on this fish. I then wrote to Dr Townsend that I had seen the skin and that I had a full account of its capture from Mr Charles T Brooks, of Cleveland, who had chartered Captain Thompson's boat and who was the real owner of the skin Dr Townsend then urged me to write up the capture in full, and suggested that as background for this I write the natural history of the fish to date This was done and when the completed MS was submitted to him, he generously offered to publish the paper in *Zoologica,* the scientific journal of the New York Zoological Society

The paper appeared in March, 1915 It was widely distributed (Dr Townsend wrote me that the edition was 3,000 copies), and it surely put the whale shark "on the map." Incidentally and happily, it started me on a series of studies on this shark not yet entirely ended

But this is not Dr Townsend's only connection with my whale shark studies Some years after I came to New York

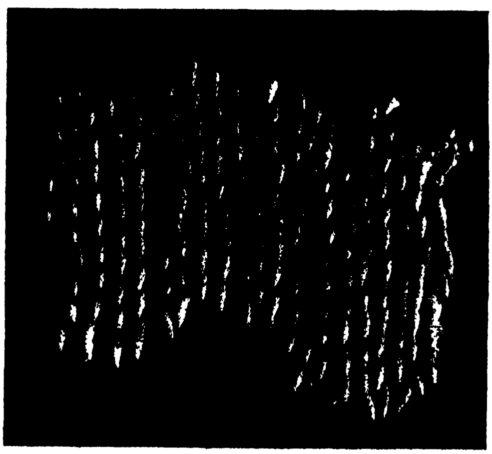
and when I was in the full swing of study and writing on the whale shark, Dr Townsend found in the archives of the Aquarium and brought to me the original drawing made for the Holders' book And incidentally it may be of interest to note that Dr J B Holder had formerly resided at Fort Jefferson, Tortugas, and that at the time his book appeared (1884) he was curator of zoology in the American Museum The drawing referred to has again disappeared, but the figure, because of its historical significance and because it led to my recognition of the whale shark and helped start me on its study, is reproduced from the book as Fig 5 herein

Since the capture of the Knight's Key whale shark in 1912, I have missed three other Florida specimens and the chances of getting a skin In 1919, the first call came, but as editor of the "Bibliography of Fishes" I was chained to it and, working against time, I could not go, but it nearly broke my heart In 1923, another fish was taken, but I was just out of the hospital and it would have been suicidal to go In 1932, the word came—too late —the great fish had been cast away But my turn and the fish and its skin were all to come to me later

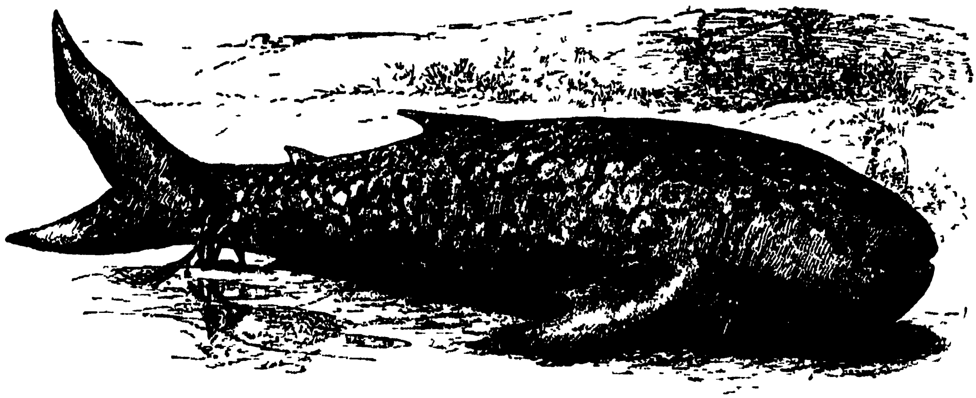
On Friday, August 9, 1935, came my great day—I saw a whale shark in the flesh On that day, a 31 5-foot specimen blundered into a pound net off Fire Island Light on the south shore of Long Island, within 50 miles of New York's City Hall It was brought in to Islip, Long Island, and I was called out to see and identify it I went and saw, but all other sharks—even up to 12½ feet long—that I had ever seen and handled before were hardly more than minnows in comparison with this colossus My excitement was great, I was unable to adjust my mind to realize how huge it was I had no standard of comparison

The story of the capture of this leviathan of the deep has been told elsewhere. Since the American Museum already had a skin, we made no effort to purchase the skin of the Fire Island fish It was secured by Mr W. K. Vanderbilt, has been mounted, and may now be seen in his private museum at Northport, Long Island

I have said that we already had a whale shark skin, and interestingly enough Dr Townsend indirectly was instrumental in its coming to us. Two years earlier a picture of a *Rhineodon,* taken at Acapulco, southwest coast of Mexico, had been sent to him at the Aquarium, with the query "What is it?" He referred the letter and picture to me The resulting correspondence led to our acquiring a skin from this region in April, 1935 And, at the time of the capture of the Fire Island fish, preparation of this skin for mounting had begun The story of how this *Rhineodon* (Fig 1) was captured at Acapulco, how the skin was sent to the museum, and how later Mr Charles T Wilson (head of the party that captured the fish) on learning of this, insisted on sending a check for the total cost of the skin delivered to the museum, has been told elsewhere But it will be interesting to take up the story at the point where that account left off



Photograph, American Museum of Natural History
FIG 4. TEETH OF A WHALE SHARK
THIS IS A FRAGMENT OF A TOOTH BAND OF A RHINEODON TAKEN AT MARATHON, FLORIDA, 1923.



After C F and J B Holder, 1884

FIG 5 A WHALE SHARK FROM THE INDIAN OCEAN

THIS SHOWS THE RELATIVE SIZE OF A WHALE SHARK ABOUT 70 FEET LONG COMPARED WITH MEN OF NORMAL HEIGHT

The skin was unpacked and scrubbed clean Next it was stretched out flat and photographed to show the relative position of the various fins and particularly of the spots and bars (Fig 6) Then it was "fleshed"—i e, all the pieces of flesh adherent to the inner side were scraped off Finally the skin was placed in a vat of tan-bark extract, where it remained for 8 months until it was thoroughly tanned. Thus prepared, it will last almost forever

The task of mounting the 18-foot skin was turned over to one of our skilled men in the department of preparation First he constructed a rough manikin of wood and chicken wire to hold his modelling clay Then, beginning in November, 1935, on this rough manikin he modeled in clay the body of the shark, "trying on" the skin scores of times, and patiently sculpturing this clay model until it and the skin fitted each other fairly well During this time his work was constantly studied and criticized by the writer and the other members of the department of fishes When all adjustments had been made to the satisfaction of every one, a plaster mold—divided into two halves right and left—was made of this model Next in each half mold there was built a half-manikin out of burlap, papier-maché and chicken wire. This was braced on the inside by a wooden framework The two halves of the model were then united, the seams covered with burlap and papier-maché and the whole shellacked Thus was created an imperishable base on which to place the skin

The manikin was next set up on a stand, and then with papier-maché and plaster this was painstakingly modeled into the final form Along with this went innumerable fittings of the skin Thus the manikin was sculptured to its final perfected form And now there confronted the preparator a new problem which had to be solved before the final adjustment of the skin was made The fibers in a shark's skin seem to run in almost all directions This makes shark leather the strongest in the world, but it certainly added to the preparator's perplexities, for our tanned shark hide was covered everywhere with a multitude of puckerings and wrinkles These by patient stretchings and rubbings were finally got out of the skin—and, at long last, the final stage, that of restoring the normal color to the skin, confronted us

In the process of tanning and of the long-continued manipulation of the wet skin in fitting it and the clay model to each other, the original color had faded out and the spots and vertical bars had disappeared. Now was realized the sound

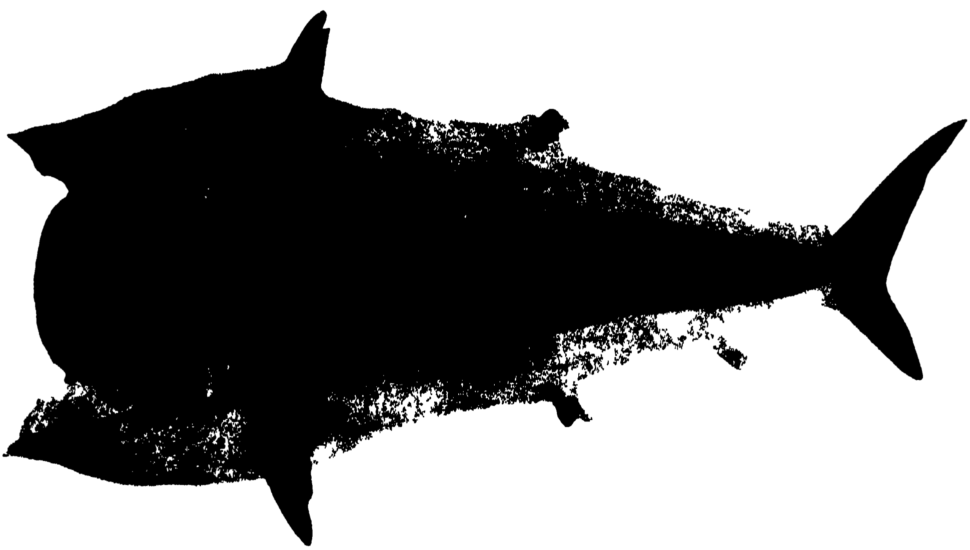
judgment shown in having a photograph made of this skin (Fig 6). This gave us the relative position and sizes of spots and bars But what was the normal ground color of the fish and what the shade of spots and bars? I had seen the Fire Island fish, but not until at least 8 hours after it had been captured The colors then, after exposure to sun, air and drying, were not the normal life colors Furthermore, I had been too excited at that time to note accurately the coloration of that fish

Resort was next had to the published descriptions But practically all these had been made from fish dead for hours The best judgment of everybody was then concentrated on the problem, and sample experimental colorings were made on heavy drawing paper draped over the fish—and no one was satisfied But just here good fortune came to our help Dr William Beebe, Mr John Tee-Van and Miss Jocelyn Crane had a short time previously returned from an expedition of the New York Zoological Society to the waters around Cape San Lucas at the tip of the peninsula of Lower California Here they had seen dozens of whale sharks, had glided alongside of them day by day. These observers were called in as referees and gave us first-hand information of the color of the *living* swimming fish With their help the final putting on of color was done and the fish coated with a dull-finish varnish to protect the skin from air and dust

It may interest the reader who cares about such matters, to get some idea of the time it took our skilled preparator to transmute the skin shown in Fig. 6 into the magnificent mount shown in Fig 7 This, it will be seen, is somewhat proportionate to the time it took me to get a whale shark skin for him to work on.

This task, from start to finish, called for an infinitude of careful, slow, minute study and work, which began in November, 1935, and ended in November, 1936—practically a year of hard work What was the cost in dollars and cents I will not set down Suffice it to say that the expenditure in money may be judged by the expenditure in time Such work can not be hurried nor skimped if one wishes a real "job"

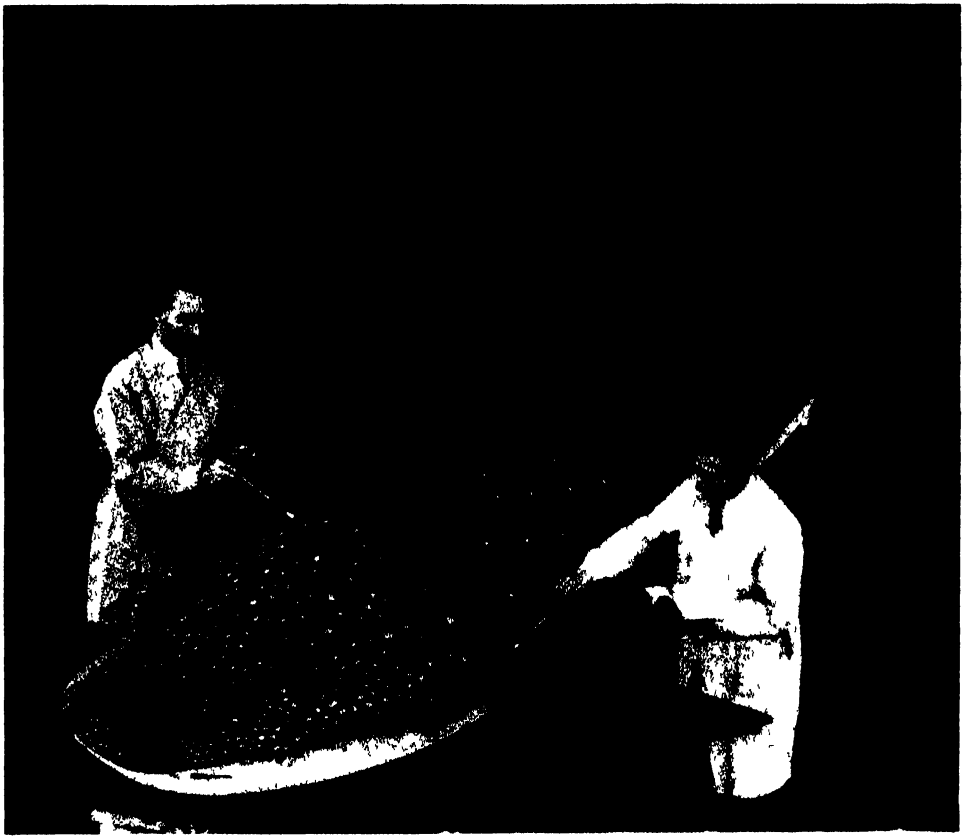
And now for comparison let us have a brief census of other mounted whale



After E W Gudger, 1935

FIG 6 SKIN OF THE ACAPULCO WHALE SHARK

THIS SKIN, MOUNTED AND WITH SPOTS AND BARS RESTORED, IS SHOWN IN FIG 7



Photograph by Thane Bierwert, American Museum of Natural History

FIG 7 THE MOUNTED SKIN OF THE WHALE SHARK IN THE AMERICAN MUSEUM

DR JAMES L CLARK, DIRECTOR OF THE DEPARTMENT OF PREPARATION, AND MR LUDWIG FERRAGLIO, WHO MOUNTED THE SKIN, ARE RESTORING THE MARKINGS OBLITERATED WHEN THE SKIN WAS TANNED

sharks as a background for this completed product

There are six mounted whale shark skins in the world's museums to-day In the Muséum d'Histoire Naturelle at Paris is the mounted skin (1860) of the specimen (the first ever described) taken in Table Bay, in 1828 In the British Museum is a Ceylonese skin mounted in 1890 The Colombo, Ceylon, Museum has a skin mounted in 1889 Another (dated 1894) is in the nearby Madras Museum In the Philippines (prolific home of *Rhincodon*) a mounted skin in the University of San Tomas has gone to pieces And so have commercially mounted and displayed skins in Japan (1901), Miami, Florida (1913), and Cuba (1930) It should be noted that none of these skins was tanned

All the museum mounts above listed are from 70 to 42 years old There are, besides our fish in the American Museum, two modernly mounted specimens A skin collected at Acapulco in 1931 was mounted under the direction of Dr Einar Lonnberg (1933) and is on display in the Riksmuseum at Upsala, Sweden Then, as noted, the skin of the Fire Island fish is mounted and is in Mr W K Vanderbilt's museum at Northport, L I This skin was not tanned—I can not say about the Upsala one Both skins are far better mounted than any of the old skins, but both fish are shown straight and lack the grace and beauty of our specimen

There are three painted casts or models to be noted A cast of 13 feet 7 inches was at last report in the Trevandrum Museum at Travancore, India Then there is our six-foot plaster model of the specimen taken at Marathon in the Florida Keys in 1923 This has been presented to the College of the City of New York in memory of Dr Bashford Dean And lastly there is a 35-foot model recently completed in the British Museum under the watchful eye of Mr J R Norman

The great day came at last—December 4, 1936 The mounted fish was done to the last minute detail Mr Charles T Wilson, who generously gave us the skin and paid for its mounting, came up to see what we had done with his gift With him came the Mexican Consul General and other Mexican friends from Acapulco where the fish was captured We received them in the hall in the Roosevelt Memorial Building in which the great fish was temporarily installed The coverings were removed, and this magnificent mount shone forth in all its beauty That these terms are not exaggerated, let the reader judge by reference to Fig 7 showing the great shark in "head-on"-lateral view

By referring to the sizes of whale sharks mentioned in the first section of this article, it will be seen that our mounted fish is a young and small specimen It measures 17 feet 10 inches over curves, but, mounted curved as it is, 14 feet 5 inches between perpendiculars The mouth is 2 feet 10 inches wide, the width over curve of head between eyes is 3 feet 6 inches, the girth just in front of the pectoral fins is 9 feet 3 inches, and the spread of these fins 7 feet 2 inches The spread of the caudal fin is 7 feet, 6 inches—18 inches greater than the height of a tall man Yet small as is this whale shark, it is far larger than the largest mounted fish in our Hall of Fishes—so large that we have been troubled to find a place in which it can be adequately displayed

This then was the consummation of my 25 years' work on the whale shark By correspondence I have pursued this great fish around the world in its three central oceans and in their dependencies By a study of the literature and by this far-flung correspondence, data have been obtained which have enabled me to make about 25 faunal records of the occurrence of *Rhineodon* in regions where it was previously unreported, or to record additional specimens in regions where it had been previously known

One would think that, because of its great size and eye-compelling coloration (the most extraordinary found on any shark), this fish would be well known and many times reported But in spite of a fine-combing of the literature since 1828, I have been able, as of December 31, 1935,[1] to find records of but 76 whale sharks captured or seen since its discovery in Table Bay, South Africa, in 1828—107 years before The voluminous data thus amassed, I have synthesized into an extensive article on "The Geographical Distribution of the Whale Shark" published in the *Proceedings of the Zoological Society of London*, January, 1935 To this the interested reader is referred

Along with the collecting of all these data has gone the amassing of the greatest collection of whale shark photographs in the world There are almost a score of these In fact, I have copies of every whale shark photograph save one, of which I have ever been able to get word But none of these, nor all of them, gives me the thrill that I experience when I gaze upon our mounted fish—the end product of a 25 years' quest

[1] Since this date, accounts (mostly very recent) have come to hand of about 25 additional specimens Some of these accounts await publication

SOME GEOGRAPHIC ASPECTS OF THE MANUFACTURE OF MEZCAL

By Dr RAYMOND E. CRIST

DEPARTMENT OF GEOLOGY AND GEOGRAPHY, UNIVERSITY OF ILLINOIS

A TRIP to Mexico is a journey to a world entirely different from our own Not only is the traveler transported to a region inhabited by people of another race, but he suddenly finds himself in another time in the history of the world, and that time is comparable in many respects to the late Middle Ages, when the guilds flourished In the Mexico of to-day household activity is very great, master craftsmen of both sexes make rugs, pottery, sandals, mats, baskets, embroidered goods, etc , and these goods are transported on foot long distances from the place of manufacture to the market

In those parts of Mexico where the maguey (agave) plant thrives either the pulque or mezcal industry is well developed—the former particularly in the more densely populated regions Pulque is the fermented juice of the maguey, whereas mezcal, the distilled liquor from the same plant, is made in primitive establishments in many parts of the country There are a few modern factories, to be sure, but for the most part mezcal is produced in small establishments which are outgrowths of household industries

The long broad leaves of the maguey plant (Fig 1) contain longitudinal fibers, known as sisal In Yucatan there are great plantations of agave plants from which is produced on a large scale the sisal or henequen of commerce, most of which goes to the United States. Here it is familiar to us in the form of small ropes or binder twine However, on the Central Plateau of Mexico and in the various dry valleys, most of the sisal is used locally to make ropes, mats, sandals, bags, etc But the stocks which remain after the leaves are cut away are not wasted They are carefully transported to the mezcal factory Here they are slowly roasted in the open courtyard on a pile of heated stones (Fig 2) Once roasted the stocks are crushed under a huge stone roller, which is pulled around

FIG. 1 MAGUEY PLANTS
FROM WHICH MEZCAL IS DISTILLED

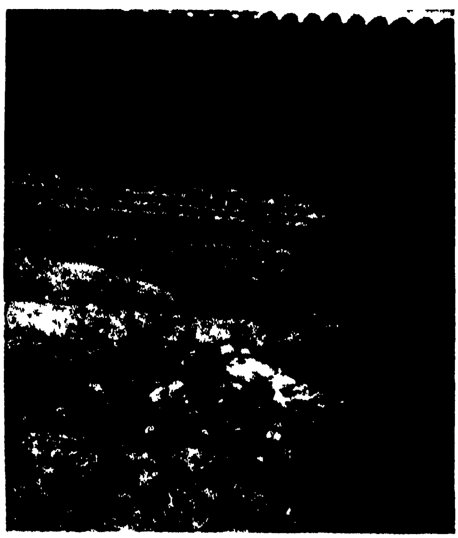


FIG 2 PILE OF STONES
WHICH ARE HEATED AND ON WHICH THE MAGUEY STOCKS ARE ROASTED

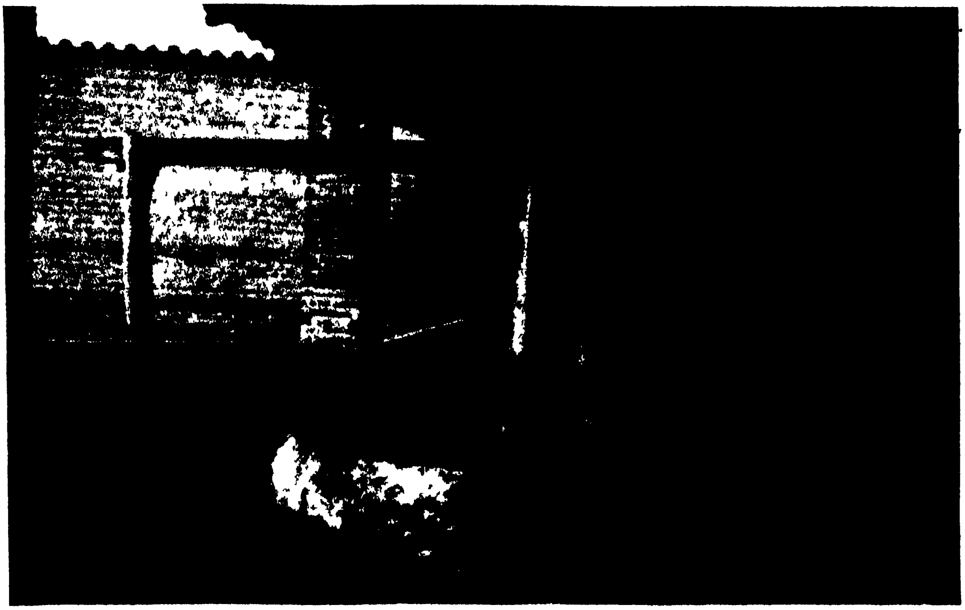


FIG 3 HUGE STONE ROLLER FOR CRUSHING ROASTED MAGUEY STOCKS

and around by a patient ox or mule (Fig 3) Thus the thick stocks are reduced to a pulp, and then the entire mass is placed in large wooden vats and left to ferment After fermentation has taken place about fifteen gallons of the mixture of brownish liquid and fibrous pulp—which smells much like ensilage—are placed in a big copper still and boiled One hour's boiling yields from three to six liters of mezcal, which is condensed in a worm which runs through a barrel

FIG 4 EMPTYING AND FLUSHING THE COPPER KETTLE USED AS A STILL.

FIG 5 FIBROUS MATERIAL AFTER BEING RUN THROUGH THE STILL

of cold water Then the kettle is emptied (Fig 4) The juice is dipped off and thrown in the yard, the fibrous pulp is carried out to a huge pile away from the building, where it is allowed to rot (Fig 5) When the kettle has been emptied, it is thoroughly flushed out with fresh water, and then another batch is added and the process is repeated

Even to the casual observer it is apparent that one of the big problems of the drier areas in Mexico is that of obtaining firewood A mezcal factory which was visited in 1938 was confronted with this same problem All sorts of material were used for firewood dried maguey leaves, gnarled stumps of small shrubs, reeds, etc

It is not always feasible to visit a mezcal factory The product is subject to a government tax However, in order to avoid paying the tax, work at the factory is often carried on without the knowledge of the local inspector At such times the owner is very wary of letting any one visit the premises unless he knows him well

The mezcal industry is a kind of overgrown household industry—there was even a little shrine in one corner of the building But such household industries are legion in Mexico and have made possible a kind of local or regional self-sufficiency—at a rather low standard of living, to be sure The introduction of a modern system of transportation is in the process of breaking up this local self-sufficiency, but it is to be hoped that the process will be so gradual that the present economy will not be completely disrupted before it can be supplanted by the economic set-up of the future—one that is intra- as well as inter-national Otherwise thousands of artisans who now have a feeling that they "belong" will no longer be able to dispose of the products of their hands, yet will not be able to fit into the new system They will thus join the urban unemployed and increase social unrest May the industrial and political leaders of Mexico keep their eyes on the past as well as on the future as they formulate current policies for their nation.

EXPLORING THE CHEMICAL CAUSES OF CANCER

By Dr. GRAY H. TWOMBLY

MEMORIAL HOSPITAL FOR CANCER AND ALLIED DISEASES, NEW YORK

OUR scene—a cold winter's day, the middle of January, 1756 The place, the great city of London, a vast multitude of small houses topped by innumerable chimney pots The good people of the city are keeping themselves warm by much Scotch wool on their backs, or by alternately toasting themselves front and back at open grates in which burn chunks of soft coal The smoke adds to the gray fog and piles up its black distillate of soot in the flues

Down the street in Southwark comes riding a rather elegant little man in a plum-colored coat Suddenly—a shout, a bustle in the narrow street, the horse rears and bolts and the little man lies in the gutter with his ankle twisted and deformed, the bone protruding through the skin on the inner side A crowd gathers and some offer to help him up, while others go for a coach

But—what sort of man is this? He looks at his own ankle, refuses the proffered help, calls after those who would get him a coach to stop, and insists on lying quite still on the cold pavement, while a man goes all the way to Westminster, some two or three miles away, to summon the two nearest sedan-chair carriers to come with their poles When they return they find he has bargained with one of the neighbors and has bought a door This is taken from its hinges and the poles nailed to its edges The door is laid alongside the man who is placed on it without disturbing the injured foot, and so he is carried through Southwark over London Bridge to his own fine house near Saint Paul's

By his amazing presence of mind and cold-blooded self-control this man has saved the protruding bone and the injured tissue from contamination with the dirt of the street or of the interior of a jostling public coach No tetanus spores have found their way to the wound And at the advice of his old preceptor, Mr Nourse, the leg is not amputated but heals by first intention

The injured man was Mr Percival Pott, surgeon at Saint Bartholomew's Hospital He was 43 years old and, although he had been one of the chief surgeons at the famous old institution for seven years, he had written only one brief case report up to this time As a result of his broken leg and his enforced idleness, he began a treatise on hernia, and so commenced a series of surgical writings which included dissertations on injuries of the head, fractures, cataract, lacrimal cyst, the cure of hydrocele, tumors of the testicle, tuberculosis of the spine, hernia and stone in the bladder, fistula in ano polyps of the nose and so forth The kind of fracture of the ankle which he sustained in his fall from his horse is known to this day as Pott's fracture His description of tuberculosis of the spine with its abscess formation, destruction of the bone and spinal deformity and paralysis, is a medical classic and has united his name eternally to that malady, Pott's disease of the spine

His writings have a modern ring which is truly surprising when one considers the time in which he lived—before the microscope, before asepsis, before anesthesia—when the learned still talked of the humors and routinely bled and purged their patients to their detriment He himself belonged to the Company of

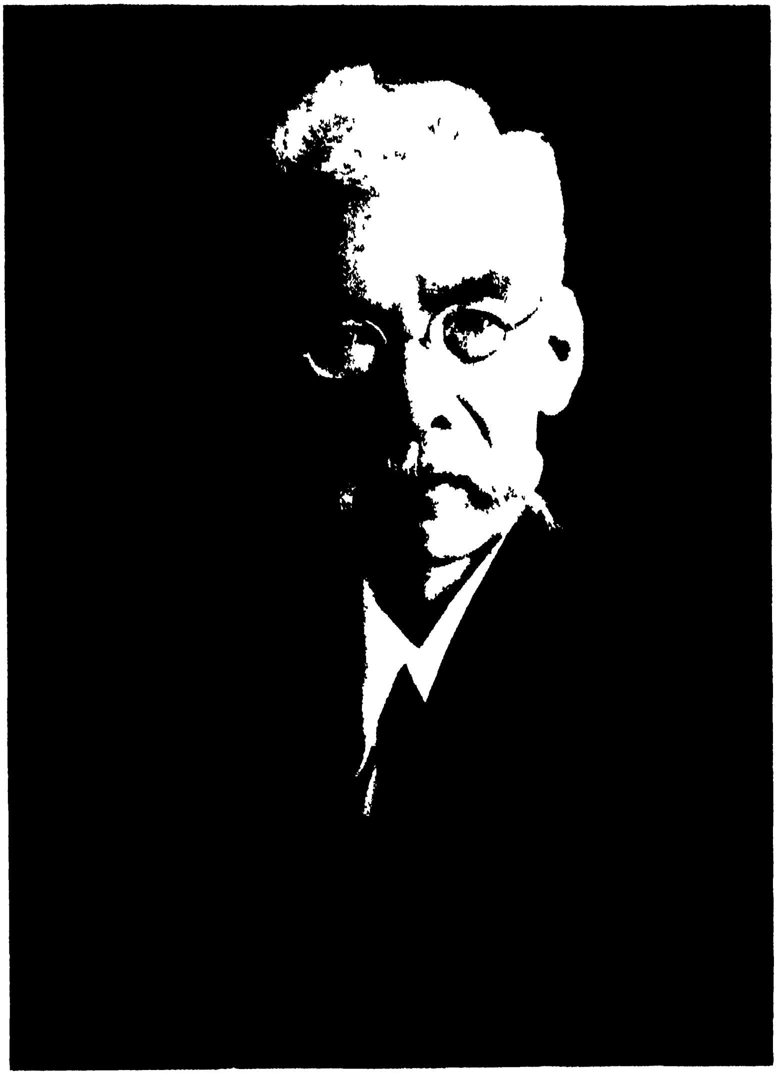
PERCIVAL POTT, ESQ
ENGRAVED BY HEATH FROM A PICTURE OF SIR JOSHUA REYNOLDS

Barber Surgeons, disbanded in 1845 In a preface to one of his works he says,

> Diseases have, it is true, in general, a sort of regularity and order, a series of causes and events, by which they are known and distinguished, yet we do now and then meet with such odd irregularities, such strange and unusual consequences, as puzzle and alarm even the soundest judgment, and the longest experience, and unless these be noted, the history of distempers will be imperfect
>
> From writers of systems and institutes (of surgery at least), such kind of knowledge is not to be expected They are most frequently mere compilers, and do little more than copy each other The information which they convey is at best but superficial, and more calculated to enable men to talk, than either to judge or to act. It must be from a careful attention to the cases of individuals, and from an observation of diseases, in their irregular and infrequent forms, as well as their more customary ones, that true and extensive judgment can be acquired

In the next paragraph he says that careful recording of the phenomena of disease "might perhaps lessen our faith in general doctrines and theories, but would render us more attentive to facts, and thereby furnish us with a much more useful kind of knowledge "

Percival Pott died in 1788, at the age of 75, of pneumonia which he probably caught because he insisted on making a round of calls on his patients on a winter's day when he was already sick with a cold He served Saint Bartholomew's Hospital "man and boy," as he used to say, for over 50 years



KATSUSABURO YAMAGIWA

In 1775 this careful observer wrote a description of a "disease peculiar to a certain set of people, which," as he says, "has not, at least to my knowledge, been publicly noticed, I mean chimney-sweeper's cancer

It is a disease which always makes its first attack on, and its first appearance in, the inferior part of the scrotum, where it produces a superficial, painful, ragged, ill-looking sore, with hard and rising edges, the trade call it soot-wart I never saw it under the age of puberty, which is, I suppose, one reason why it is generally taken, both by patient and surgeon, for venereal, and being treated with mercurials, is thereby soon and much exasperated

The fate of these people seems singularly hard, in their early infancy, they are most frequently treated with great brutality, and almost starved with cold and hunger, they are thrust up narrow, and sometimes hot chimneys, where they are bruised, burned, and almost suffocated, and when they get to puberty, become peculiarly liable to a most noisome, painful, and fatal disease

The disease, in these people, seems to derive its origin from a lodgement of soot in the rugae of the scrotum

RICHARD VON VOLKMANN
AS SURGEON IN-CHIEF IN THE GERMAN ARMY DURING THE WAR OF 1870–1871

This observation of Pott's forms the basis for our present knowledge of the possibility of producing cancer with pure chemicals and this in turn bids fair to provide the key, or one of the keys, with which we may unlock, perhaps, the secret of cancer formation, prevention and cure, in the future. The story is a fascinating one and apparently is only in its early chapters. It would certainly enthrall Pott, for it is a story of observation and not of theory.

Pott's discovery was one which could have been made easily only in England where, as was mentioned to start with, the common form of heating for homes is soft lignite coal burned in an open grate. Chimney-sweep's cancer does not occur or, at least, occurs with the utmost rarity in America. At the Memorial Hospital in New York, where more than 3,000 new cases of cancer are seen every year, the only cases related to this disease are not true chimney-sweep's cancer at all but have occurred in workers in oil refineries, gas works, coke plants, etc., and even then there are only nine cases on file. Pott's observation was passed on by "writers of systems and institutes of surgery who do little more than copy each other," as he says, for a hundred years.

Had one journeyed to the City of Halle in Saxony in 1875 and gone to the University Surgical Clinic, one would have seen, without doubt, a man of medium height but with a commanding personality who sported a most impressive set of Dundreary whiskers and who was soon to become, through his extensive surgical observations and writings, one of the most prominent surgeons of Europe. His name was Richard von Volkmann and he was the chief of the surgical clinic and one of the first men to successfully use the antiseptic method in Germany. His writings included not only contributions to orthopedic surgery, the description of an improved method of removing the rectum for cancer, how to operate on cysts of the liver and operations for tuberculous joints, but a delightful book of fairy stories which he first wrote as letters to his children when he was waiting wearily with the German Army outside the gates of Paris for its surrender in the wintery siege of 1870–1871. This man was also a keen observer like Pott and wrote of what he saw rather than what people had said in the past. He described three cases of cancer of the scrotum occurring in men engaged in the manufacture of paraffin from lignite. He went into great detail over the chronic dermatitis which these workers

showed after a short time in the factory. Although the irritation of the skin was widespread, the tumors appeared usually, strange to say, on the scrotum only Volkmann called attention to the similarity of this affliction with the cases described by Pott His observations suggested the presence of a chemical or chemicals in coal-tar as a cause of cancer rather than the mere irritation from dirt and grime which might have accounted for the cases in chimney-sweeps

Our tale having started in England, then gone to Germany, now jumps to Japan where, at the beginning of the twentieth century, the bright young men were looking with admiring eyes at the culture of the West and many were coming for study with the great scientific leaders in Germany One of these was a man called Katsusaburo Yamagiwa He was born in 1863 and studied medicine at the Tokyo Imperial University, where he graduated in 1888 In 1891, when at the age of 28, he had just become assistant professor of pathology, the Japanese Government sent him to Germany to study under the great Robert Koch, the discoverer of the tubercle bacillus However, when he arrived, he found there a man he disliked and disagreed with, Dr Kitasato This led him to desert Dr Koch and work instead under the direction of the great Rudolph Virchow, the "father of pathology", and so was laid the way for the discovery which has made the name Yamagiwa known and remembered all the world around Virchow believed cancer to be due to chronic irritation Following out the idea of his teacher, Yamagiwa, as professor of pathology in Tokyo in 1913, set one of his graduate students, Ichikawa, to the problem of trying to produce cancer, first with scarlet red and then with tar How odd the ways of Dame Fortune! In 1899 Hanau had painted animals with tar for long periods of time without producing cancer but he had used rats and the skin of the rat, as we know now, is very resistant to cancer production by tar, though the reason is still obscure Cazin in 1894 had done the same with the dog. Haga in 1913 used the right animal but did not have patience to continue the treatment long enough, and so it was left for these two undiscourageable Japanese to make the great discovery that long-continued painting of the ears of rabbits with tar would ultimately result in cancer, and this fact they published in 1915 For the first time it was possible to produce cancer of the skin at will with a chemical agent It was shown soon after that mice were even more susceptible than rabbits

Yamagiwa was a simple man, whose only diversion outside his laboratory was writing poetry He was afflicted most of his life with tuberculosis. He was always poor in money but rich in the love and respect of his students, so that when he retired from active teaching they banded together and bought him a house, the only one he had ever owned He died in 1930

An austere, intellectual, successful English surgeon, a German Geheimrat who wrote children's fairy tales, and an impecunious, patient, conscientious Japanese who wrote poetry—they pass before us a strangely assorted trio, but all three united by their thirst for truth and their unswerving reliance on observation rather than theory.

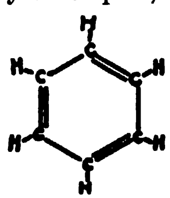
Our interest turns now from the individualities of the investigators to the fascinating development of the problem itself, partly because we are too near the subsequent discoveries to see the men who made them in their right perspective and partly because the number of men concerned is too great. These discoveries form an intriguing tale in themselves, a tale hardly begun and rich with future possibilities.

The greatest strides next to be made were the products of a group of workers led originally by Archibald Leitch at the

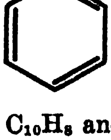
Royal Cancer Hospital and now by Ernest L Kennaway since Leitch's death in 1931 Their goal was the discovery of which one of the multitude of chemical compounds in coal-tar was responsible for cancer formation Kennaway made an important step in this direction when he found, in 1925, that acetylene, $HC \equiv CH$, heated to 700° C yields a cancer-producing tar. This material obviously must be made up of carbon and hydrogen—that is, must be a hydrocarbon, thus eliminating the other elements and suggesting that the active material is composed of benzene rings hitched together in some fashion

Leitch and Kennaway had collected many different types of cancer-producing agents, some made by distillation at varying temperatures from various types of coal-tar and paraffin oils, and even from human skin and muscle, and others synthesized from acetylene and isoprene W. V Mayneord, the physicist at the same institution, pointed out that many showed a characteristic fluorescent spectrum with bands at 4,000, 4,180, and 4,400 Angstrom units and this was further elaborated by Dr Izrael Hieger, who examined 750 such substances with his spectroscope The use of the spectroscope in the search was truly a long jump along the road of discovery The supposition that these bands were related to cancer production was a large one but to the person who thinks of the magnitude of the problem the laboratory had set for itself, to pick out of the million possibilities the one chemical combination in coal-tar able to cause cancer, the proof that this guess was correct tells of the saving of years of work Hieger noticed that 1 2 benzanthracene showed the same bands as the known cancer-producing agents, though itself inactive, except that their absolute position in the wave-length scale did not correspond exactly. He drew the conclusion that increasing the mass of the benzanthracene molecule might shift the bands in the right direction A method of making 1 2 5.6 dibenzanthracene had just been published by a German chemist, E Clar, entirely apart from any thought of cancer research. On Hieger's assumption Dr J W Cook synthesized this material and it was tested in mice and shown to be strongly cancer-producing when applied in a solution of benzene Tumors so produced were exhibited at the meeting of the British Medical Association in July, 1931, by Dr Cook Burrows, Hieger, and Kennaway injected the same substance, dissolved in lard, subcutaneously into rats and mice, hoping that it might produce cancer of the bladder They found that it failed to do what they had hoped but it did produce sarcomas, cancers of connective tissue, in 31 out of 93 mice, and in 15 of 67 rats These observations were published in January, 1932

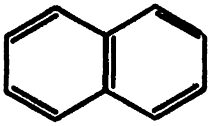
What do we mean when we speak of 1 2 5 6 dibenzanthracene? As all who have studied organic chemistry remember, benzene is C_6H_6 and the structure is thought to be a hexagonal arrangement of the carbon atoms, each attached to two others and to one hydrogen atom, the fourth valence bond of the carbon atom being represented as a double bond between every other pair, thus



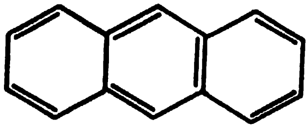
Actually the fourth bond may be across the ring. Conventionally the carbon atoms and hydrogen atoms are not written, the formula being expressed merely by a hexagon



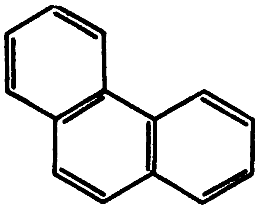
Naphthalene is $C_{10}H_8$ and is written



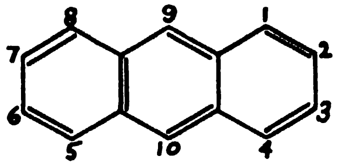
Anthracene is $C_{14}H_{10}$ and is written



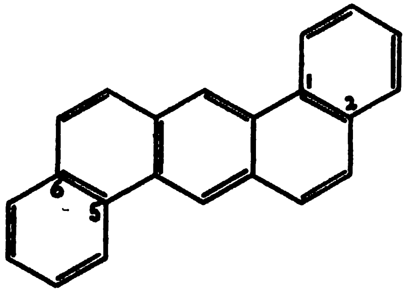
The benzene rings in this case are in a straight line If they are not in a straight line, one has the compound called phenanthrene



To simplify the nomenclature, the positions of the carbon atoms in anthracene are numbered thus

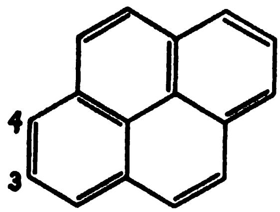


It is easy to see what 1 2·5 6 dibenzanthracene must be, the name obviously meaning that two additional benzene rings are added to anthracene in the 1 2 and 5:6 positions

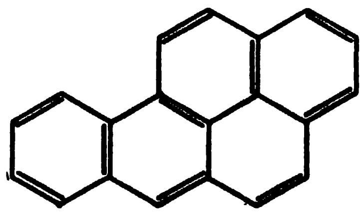


It was this compound which was first shown by the London group to be a pure hydrocarbon having, to a fairly high degree, the ability to produce cancer Strange to say, this substance does not occur in coal-tar and is not the substance causing cancer in chimney-sweeps or tar-workers so far as we know It was discovered by reasoning from what was known about cancer-producing fractions in coal-tar rather than by extraction from these fractions

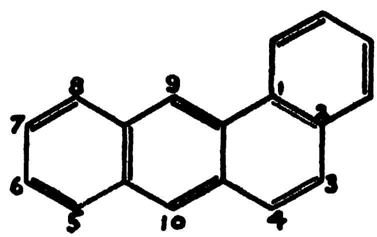
It was only a year before Cook, Hewett and Hieger had found another related substance, this one very much more potent in cancer-producing power and occurring in the cancer-producing fractions of coal-tar Hieger isolated 50 grams of it from two tons of gas works pitch It is known as 3·4 benzpyrene and is considered to be pyrene



with a benzene ring in the 3 4 position—thus



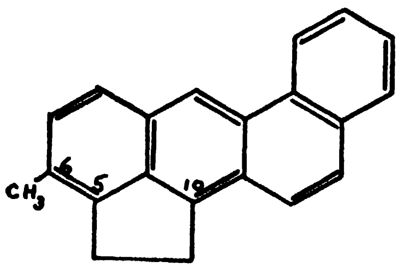
Notice, however, that it also may be considered to be 1·2 benzanthracene



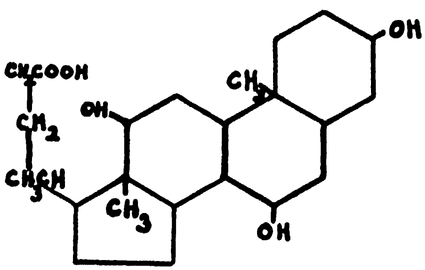
with a benzene ring in the 9 position This substance has been known to produce cancer in the skin of mice in as little as 30 days A tumor has occurred in a rat 25 days after subcutaneous in-

jection It has produced cancer in the mouse in doses as small as 0 4 mg

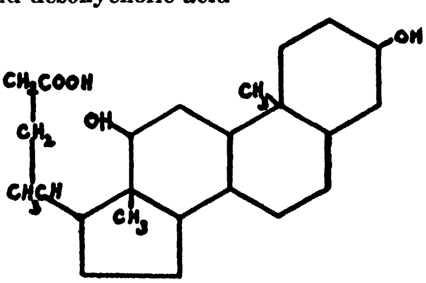
In 1934 a third substance, methylcholanthrene, synthesized simultaneously by Wieland and Dane (in 1933) and by Fieser at Harvard, was found by Cook and Haslewood to be even more powerful as a cancer producer than 3 4 benzpyrene This compound is of great interest from the theoretical point of view as will appear when its structure is explained It consists of the 1.2 benzanthracene nucleus (see last diagram) to which is added a methyl group at position 6 and a cyclopenteno (five-membered) ring at position 5 and 10, thus



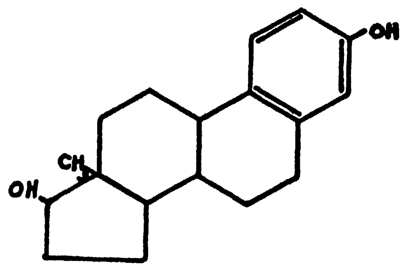
Now the two principal acids occurring in bile are cholic acid



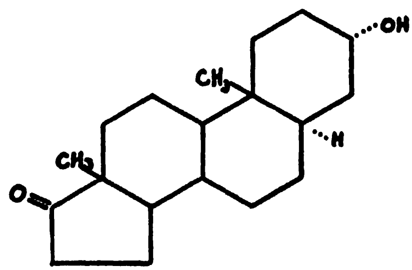
and desoxycholic acid



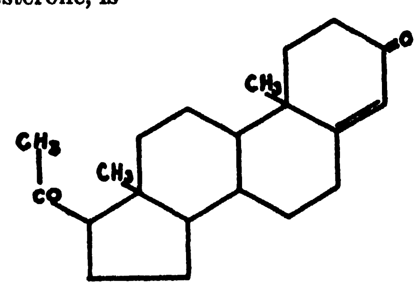
The original synthesis of methylcholanthrene was done by four simple chemical transformations from desoxycholic acid Later Fieser and Newman at Harvard reported a similar series of transformations from cholic acid. This immediately suggests that cancer arises in human beings as a result of similar reactions taking place in the body, changing cholesterol or one of its derivatives, the bile acids, into a cancer-producing substance, such as methylcholanthrene which in turn produces the cancer This hypothesis was particularly attractive since many of the substances, known as sterols, which are of great importance in the body have chemical structures which suggest the above diagrams. For instance, the female sex hormone from the ovary, oestradiol, may be written



and the male hormone, androsterone, so

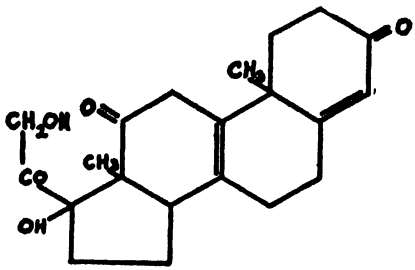


The hormone from the corpus luteum, another important hormone called progesterone, is

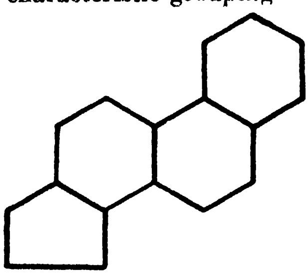


The adrenal hormone is not agreed upon

but Marker suggests that its formula is



Similar formulae represent related hormones, such as oestrone and oestriol, two other female sex hormones, and testosterone, a male hormone Vitamin D is derived from ergosterol and it in turn has the characteristic grouping



The same is true of alkaloids of the digitalis and saponin groups, substances having very marked physiological actions

However, it is one thing to point out superficial structural resemblances of these substances and quite another to say that transformations of one into another take place in the body, even though in the test tube one can make methylcholanthrene from the bile acids Can or does such a thing occur in the body? Our evidence must be very indirect in lieu of more studies not yet made, although already begun, on the changes undergone by both carcinogenic chemicals at one end and hormones at the other. What sort of evidence do we have?

First, it is interesting that benzpyrene will give the same hormonal effects as the female sex hormone, that is, it will produce the state known as heat or oestrus in the castrated female mouse or rat; the female will accept the male though she will not do so if she is castrated and untreated or even if she is normal unless she is in heat This same effect is produced by another carcinogenic hydrocarbon, 5 · 6 cyclopenteno 1 : 2 benzanthracene However, the significance of these observations is greatly diminished when we find that it takes very large doses of the cancer-producing hydrocarbon to cause oestrus, much larger than needed to yield cancer, and this property is shared by many substances quite unrelated chemically to either the sex hormones or the cancer-producing substances

Another approach to the problem has been made by the successful production of cancer with the hormones Nevertheless the conclusions we reach from this line of attack must be very guarded as will be seen

The story goes back to some work of Leo Loeb, who first showed that if one started with a pure-bred race of mice, in which a large proportion of the females developed cancer of the breast if they lived long enough, and castrated the females before they were three months old, very few would subsequently develop cancer The corollary of this was provided by the work of Murray, who transplanted ovaries into young castrated male mice of high cancer strains and so produced cancer of the breast in a few of these animals when they grew old. Lacassagne, working on these observations, injected female sex hormones into male mice from high cancer strains, and by starting when the animals were 10 days old and giving the largest possible doses he was able to produce a high proportion of breast tumors in the surviving animals. These male mice almost never develop breast cancer spontaneously

But notice that this experiment will only succeed in animals in which the females show breast cancer spontaneously, only in animals injected with the largest possible doses from a very early age, and

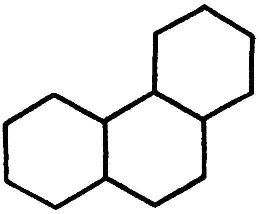
that the cancer occurs in the breast and not at the site of application of the hormone The female sex hormones have the ability to produce marked development of the breast tissues and it is yet to be proved that these cancers occur directly as a result of the action of the hormone Perhaps the hormone merely develops the male mouse's breast to such an extent that it becomes like the female's, a fertile soil, so to speak, for some other agent to work on and cause the cancer.

Lacassagne, the Yale workers, and MacEwen all report occasional cancers of the connective tissue or fat at the site of hormone injections, suggesting a direct cancer-producing action of the hormones. However, these always have been injected repeatedly in an oil solution and it is well known that the injection of oil alone in rats and mice, repeated often enough, will cause an occasional cancer

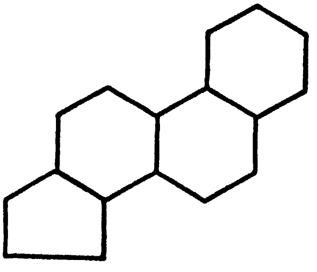
So far we know very little about the changes taking place chemically in the female sex hormones after injection into the body. For the most part they are acted upon very quickly, only a fraction of the material injected can be recovered in recognizable form. As yet we do not know enough to say that they are ever changed in the body to resemble any of the known cancer-producing substances

It is well to say here, parenthetically, that the danger of causing cancer in women with these materials used as medicines is yet to be demonstrated Cancers in animals are only produced when the drugs are used in the largest concentrations possible without killing the animal, in repeated injections from early in life to the death of the animal and do not succeed if started in adult animals No authentic cases are recorded in women Occasionally one hears of a woman developing cancer of the breast or uterus after intensive hormone treatment but closer investigation usually shows any connection between the two to be quite unprovable Either the cancer was probably present before the injections were given or the dose was too small to conceivably produce the tumor, or the simultaneous development of the tumor with the injections was coincidental. Those who have given the largest amounts to the greatest number of cases all seem to agree that in their experience they have seen no cancer developing from the therapeutic use of hormones.

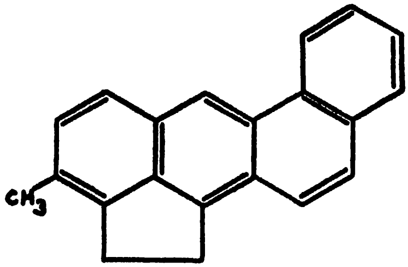
We come now to a brilliant piece of research attempting to answer the same question, *i e* whether cancer production and the naturally occurring sterols are related The chemical syntheses were carried out by Fieser and his coworkers while M J. Shear did the animal experimentation You will have noticed that all the sterols mentioned above had a phenanthrene nucleus



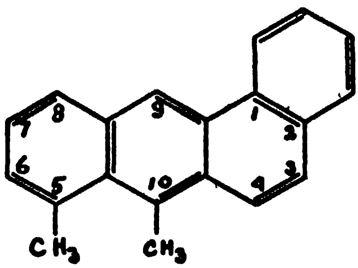
to which was added a cyclopenteno, or five-membered ring.



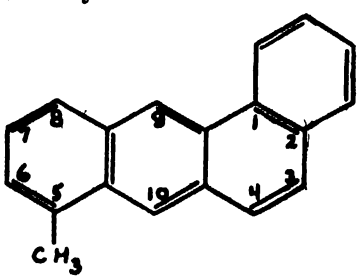
If this ring, which occurs in so many biologically active substances, were shown to be of importance in cancer production it would link the latter more closely to the sterols in the body. To answer this question Fieser prepared a series of substances which were tested by Shear for their cancer-producing quality. The formula of methylcholanthrene, you remember, is



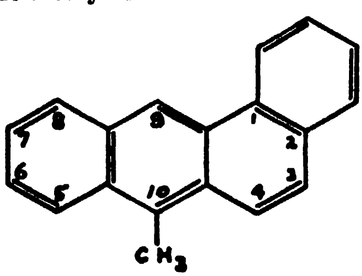
Fieser first made cholanthrene which is similar but lacks the methyl (CH_3) group Removal of this group was found to affect the cancer-producing property of the substance very little Next he split the five-membered ring, making 5:10 dimethyl 1:2 benzanthracene.



Here he had gotten rid of the ring but found that he had retained the cancer-producing potency Finally he made both 5 methyl 1·2 benzanthracene

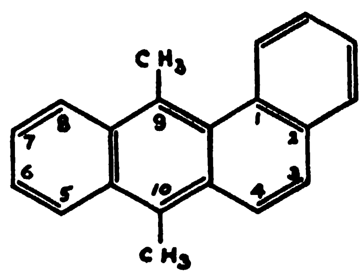


and 10 methyl 1·2 benzanthracene.



Of these, the 5 methyl compound was weakly cancer-producing while the 10 methyl compound was almost as potent as methylcholanthrene itself. And so he had proved that methylcholanthrene is a strong cancer-producing agent, not because it has a five-membered ring and is related to the naturally occurring bile acids, hormones and vitamin D, but because it is a 1 2 benzanthracene with a substitution group in the 10 position. This demonstration weakens, though it does not abolish, the theory that cancer arises in the body from the formation of a cancer-producing compound by the faulty metabolism of one of the sterols

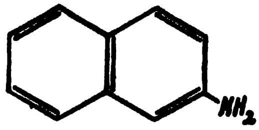
The subsequent course of this research both by Fieser and Shear and by the London group has led to the synthesis and testing of all of the possible monomethyl substitution products of 1:2 benzanthracene It has been found that only the 10, 9, 5, 6 and possibly 7, compounds are cancer-producing and in that order of potency, 10 methyl 1:2 benzanthracene being the strongest Remember that benzpyrene may be considered a 9 substituted 1 2 benzanthracene This last year, 9 10 dimethyl benzanthracene has been made and has been found, as one would expect, to be the most potent substance so far obtained in giving cancers of the skin in mice, although, strangely, it does not cause connective tissue tumors



It would be wearisome and perhaps meaningless to describe or even list all the substances related to 1:2 benzanthracene or phenanthrene which have been found to be cancerigenic. Suffice it to say that in a recent review, Fieser lists 49

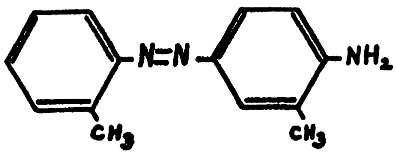
which have been reported as giving tumors, at least by one worker How many of these will stand the test of time and how many are really cases of tumor caused by the oil in which they were injected is hard to say. At any rate they merely add, for the most part, a long series of pure chemicals as causes of cancer formation to the list of other stimuli which we have known from clinical and laboratory observation to be cancer producers One point which should be brought out in passing is that perhaps the reason the chimney-sweep's cancer and the tumors Volkmann described in tar-workers only occurred on the scrotum is that most of these materials are fat-soluble and not water-soluble In the skin of the scrotum are very abundant sebaceous glands often containing a large amount of fatty material in which the cancer-producing hydrocarbons could readily dissolve and be kept in contact with the tissues for long periods of time

We turn now to a number of hydrocarbons which are most interesting because they produce tumors not at the site of their entrance into the body but in some distant organ or tissue They are related to the substances of which we have been speaking in that they are all derivatives of coal-tar but otherwise they are structurally quite different The simplest of these is beta-naphthylamine long

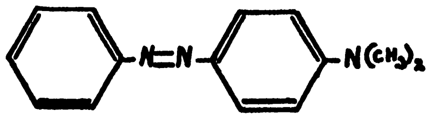


suspected as the cause of tumors of the bladders in anilin dye workers and finally used successfully in the production of such tumors in dogs by Hueper, Wiley, and Wolfe in 1938 The drug was given subcutaneously or by mouth. The tumors were in the bladder

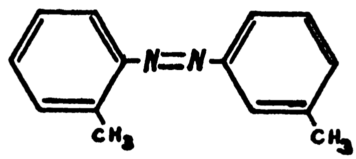
In 1935 Sasaki and Yoshida, two Japanese workers, injected O-aminoazotoluene under the skin of mice and obtained



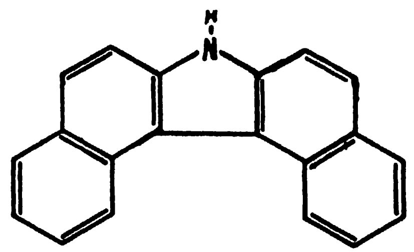
thereby tumors of the liver Similar tumors were produced by Kinosita in 1937 with P-dimethylaminoazobenzene, a substance known as "butter-yellow" and used commercially as a dye for col-



oring oleomargerine or other vegetable fat substitutes for butter A related compound 2 3′ Azotoluene causes cancer of the bladder (Otsuka and Nagao, 1936)



3 4 5 6 Dibenzcarbazole produces not only cancer of the skin at the site of application but also tumors of the liver according to Boyland and Brues (1937)



So we see that chemical agents can bring about the formation of tumors at a distance as well as at the site of application and in this group will be included the hormones, if some day they are proved to be themselves truly carcinogenic

It is all very well to list the various ways one can produce cancer and it is very nice to be able to make cancers with some pure chemical, the name of which

most people cannot remember or pronounce, but neither procedure answers the great questions of why and how these substances work Are we any nearer to the secret of unrestrained growth or the prevention or cure of cancer, or have we merely listed a new set of industrial hazards related to coal-tar? Here we are truly in a practically unexplored field A few tentative lines of research have been thrown out but so far they do not lead a great way Haddow, for instance, finds that all of these potent hydrocarbons are inhibitors of cell growth One can stunt a young animal permanently by injecting it with methylcholanthrene Often the cancer-producing chemical can be told from one which does not produce cancer before either is actually tried out by seeing what effect it has on the weight curve of young growing rats So marked is this growth inhibiting effect, in fact, that these hydrocarbons have been used to treat locally clinical cancer in man, with a modicum of success It slows up the local growth

Haddow points out that if one keeps certain bacteria of the typhoid group under unfavorable conditions (by keeping them growing a long time on the same culture media) some will suddenly change and become able to utilize types of sugars in the media which they previously were not able to use as food He draws an analogy between this and cancer production The cells in contact with the cancer-producing hydrocarbon are not killed by it but some of their life processes (perhaps some of the enzymes connected with cell respiration) are interfered with The cell fails to grow and has difficulty in surviving until suddenly it mutates or changes in some unknown way and becomes able to use as food, tissue juices or blood plasma which previously it could not Such a change would result, possibly, in unrestrained cellular proliferation, the process we call cancer

Fieser has attacked the question from the purely chemical side and points out that while the potent cancer-producing compounds related to benzanthracene are rather inert chemically, they can be attacked and oxidized by lead tetra-acetate and can be diazotized and both of these reactions take place at the positions on the benzanthracene nucleus which are of the greatest importance in making potent compounds, the 10 and 9 positions He believes cancer-producing potency to be related to some peculiar chemical reactivity greatest at these points

Boyland and Levi, and more recently Rhoads and Dobriner, have tried to find out what becomes of 1.2 5.6 dibenzanthracene in the body and have discovered that animals which differ in their susceptibility to this substance differ in the way they metabolize and excrete it The rabbit, though tumors of the skin were first produced in it, is very resistant to the action of any of the cancer-producing hydrocarbons when they are injected under the skin Only one paper has reported the successful induction of such tumors and even then only in a few animals Is this resistance related to the fact that the break-down products of dibenzanthracene in the rabbit are entirely different from those in the rat or mouse?

Nakahara, using "butter-yellow" in rats, says that those fed a large amount of liver or yeast fail to get the cancers of the liver which appear in the control animals Does the cancer-producing action have something to do with vitamins, especially the B complex which occurs in abundance in liver or does it inhibit liver cell destruction and the consequent regeneration which goes over into cancer? Pure vitamin B does not have this protective action Possibly a very fertile field would seem to lie ahead of the person looking for the effects of various vitamin-deficient diets on cancer production with hydrocarbons It is almost unexplored

At the last meeting of the American

Association for Cancer Research, G H. A. Clowes reported some very interesting experiments in which small additions of benzpyrene and methylcholanthrene produced marked changes in the physical characteristics of monomolecular films of cholesterol and ergosterol, suggesting that these substances act by altering the nature of the cell membranes where lipids play such an important role

Where will the search lead us? Here is the chemical How is it changed in the body? What does it do to the cell? How is it related to the virus of fowl tumors, if at all? A thousand questions arise. How tantalizing to see the changes taking place in the animals' cells right under our eyes as we gaze through the microscope and not to be able to say how or why!

It seems necessary to offer an apology for such a cursory survey of so vast a field. We have described only a few of the important points and have undoubtedly failed to mention many discoveries of the utmost value.

It often seems to me that cancer research can be likened to the exploration of some vast unknown island such as New Guinea We can sail around it and land on any side to try to make our way into its inner fastnesses The easiest lanes into its interior are like rivers leading up toward the mountains of promise Pott, Volkmann, and Yamagiwa were the bold explorers who first charted the mouth of one of the rivers Others have sailed up it many miles, and we have just been with them to the head of navigation and seen some of the tributaries up which men are forcing their way, knowing not whither they lead. We have said nothing of the other great rivers, such as the genetic attack, the virus approach, the stream of pure physical research, or that of endocrinology, though we have taken a brief peek over the watershed into that valley. Ofttimes the men trying to beat their way inland from that hard and rockbound coast called clinical research, characterized by its difficulty but perhaps by its closeness to the final secrets, wonder whether those on the other side of the island, sailing the rivers are really exploring the same island or heading for the same goal "What has tar to do with the cause and cure of cancer in my patients?" exclaims one. Or "How can rats and mice or fruit flies mean anything to me?" says another

Some explorers go off into the wilderness alone and return with strange and fascinating tales, often true but hardly believable until seen by others. Many such tales are no more than mirages or the figments of vivid imaginations told to the admiring public and, as Pott put it, "more calculated to enable men to talk than either to judge or to act"

The quest is vast and alluring. Streams asking to be explored lead away on all sides One must try to pick the largest and most navigable if one is to do more than become lost in the dense jungle The quest is exciting and moves rapidly. Treasure may lie anywhere. One wishes for six heads to hold all the knowledge he needs, a hundred hands, the best equipment, and 48 hours in a day When will the goal be reached or will it ever? Who knows? But how exciting to go and try!

THE SPACE IN WHICH WE LIVE

By Dr. PAUL R. HEYL

NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.

OUR ideas of the space in which we live have undergone a development or evolution in common with our ideas of all the other wonders in nature round about us. Primitive man's attempts to explain natural phenomena were animistic, often anthropomorphic. Each tree was inhabited by a spirit or tree-nymph, called a dryad; the electrical properties of amber were due likewise to an indwelling spirit who could be roused to action by the rough treatment of friction; Roger Bacon, the greatest scientific mind of the thirteenth century, still held to the ancient belief that the heavenly bodies were carried about by angels Such primitive scientific theories had the advantage of being readily understood by everybody, which is more than can be said of their modern successors Scientific theories have followed Spencer's formula in their evolution, proceeding "from the homogeneous to the heterogeneous," from the simple to the complex, and have now in some cases reached a degree of complexity which makes them incomprehensible to the multitude and rather appalling even to those professionals who feel that they must make the attempt to follow their development

In man's earliest ideas of space there were two characteristic features. One was its geocentric architecture. It was a natural induction from the apparent motions of the heavenly bodies that they all revolved about the earth as a center Such a theory, moreover, by placing man at the center of the universe, tickled his vanity, and furnished a powerful motive for the opposition to the later Copernican astronomy.

A second characteristic of space as conceived by early man was its finite and relatively small extent It is difficult for us, familiar as we are from childhood with the idea of the immensity of space, to realize how small the ancients thought the visible universe to be The Greeks placed the abode of the gods no farther away than the summit of Mount Olympus, Omar Khayyam speaks of

> that inverted bowl we call the sky,
> Where under crawling, coop'd we live and die.

The legend of Mohammed's nocturnal round trip from earth to heaven, mounted on a miraculous steed, was a natural outgrowth of the limited idea of space common in his day Such a story, even when colored by the supernatural, would have been incredible and could not have taken root in the background of such space ideas as those with which we are familiar. The proud boast of the builders of the Tower of Babel, "Go to, let us build a tower whose top shall reach unto heaven," is not to be regarded entirely as a figure of speech.

The change from these ideas to those prevalent to-day has been so revolutionary that we have not yet entirely adjusted ourselves to it. The world of the ancients, at the center of a comparatively limited universe, was a rather cozy and comfortable place. The sun, moon and stars shone for man's especial benefit and pleasure; the gods were never so far away that they could not drop in unexpectedly for supper, if they felt so inclined Contrast this with the position in which we find ourselves We are but microscopic parasites on the surface of an insignificant planet, attached to a third-rate star. About and beyond us space stretches its dizzying immensity, be-

strewn with stars like our sun, some larger and brighter than our luminary, others much smaller Our cosmic emotion to-day contains an element of loneliness We have so much more room than we really need, and our nearest neighbors are so far away! Nevertheless, we must make the best of our situation, and perhaps we shall be most successful in this if we follow the scientist's way, and learn what we can about this great and wonderful space and its contents

The visible contents of space, the sun, moon, stars and planets, have been the objects of man's study and attention from remote antiquity, and this study has not been without its fruits We have learned to measure the distances of the stars, and even to make chemical analyses of the glowing gases that make up their atmospheres We have found that the brightest stars are not necessarily the nearest to us, and that the so-called "fixed" stars are actually in motion with high velocities, which great distance renders almost imperceptible We find stars grouped together in clusters and nebulous patches, such as the Milky Way Some of these nebulae can be resolved by the telescope into their star-components, others, irresolvable in this way, have been shown by the spectroscope to consist of large masses of glowing gas

Many of these nebulae, on spectroscopic evidence, seem to be receding radially from us in all directions, with velocities which increase with their distance. This extraordinary state of affairs has raised a question as to the proper interpretation of the spectroscopic evidence Are we to interpret it as we usually do in the case of bodies comparatively near us or is there some hitherto unrecognized law of light which over an immense distance of travel simulates the optical effect of a receding body?

We do not know as yet, but for the sake of those of us who are cosmically minded it is to be hoped that these velocities of recession are only apparent. If real, it would be a blow to our self-esteem, for it would suggest that in the distant past these nebulae were so near us that they learned all they wanted to know about the way in which man conducts his affairs on this planet, and have never stopped running

Among the most interesting bodies in space are those which we can not see at all—the dark stars and nebulae Such dark stars as we have been able to detect are parts of a double star system, the light of the bright component being periodically eclipsed by the dark star in its revolution about it It is probable that many other dark stars exist which we have no means of recognizing.

Dark nebulae are also to be found here and there, becoming evident when they are seen as dark patches against the background of a luminous nebula One of these black regions, known as "the coal sack," caused the astronomer Herschel, when it drifted into the field of his telescope, to exclaim to his sister: "Surely, here is a hole in heaven!"

Stars, star clusters and nebulae, bright and dark—such are the contents of the space in which we live These are wonderful indeed, but the very space itself, in which they live and move and have their being, is a greater wonder and a more mysterious puzzle

Our earth circles round the sun at the rate of 18 miles a second. What force holds it in its orbit and prevents it from flying off at a tangent, like drops of water from a rapidly rotating grindstone? The force of gravitation, we say. We repeat these words glibly, but do we realize the magnitude of this force? Calculation shows that the centrifugal force of the earth in its orbit would snap a steel cable 5,000 miles in diameter! And yet space, "empty" space, holds the sun and the earth together.

But this is not all. Let us pile Pelion upon Ossa.

The earth receives from the sun a continual stream of light and heat, representing in the aggregate a large amount of energy. How does this energy get across the empty space between the sun and the earth?

Lodge, in discussing this question, puts it in this way Suppose there is a dog lying asleep a few feet from us How can we attract the dog's attention? We might prod him with a stick, we might throw a stone at him, or we might whistle or call to him. In either of these ways we might convey sufficient energy to the dog to furnish the needed stimulus.

In the case of the sun and the earth the stick is obviously ruled out of consideration, but the stone is a possibility to be considered In Newton's day and for a century afterward it was believed that light consisted of a stream of very minute corpuscles shot out from the luminous body This theory accounted well for the straight line travel of light and for several other facts of observation, but there were difficulties also One of these was encountered when it was discovered that light traveled with the enormous speed of 180,000 miles a second Speaking in modern terminology, a particle weighing one millionth as much as a grain of sand, and traveling with the speed of light, would have as much energy as a rifle bullet How could such a delicate organ as the eye withstand machine gun fire of this nature for a lifetime without injury? The only possible answer was that the light corpuscles must be inconceivably minute, and since indefinite retreat was possible in this direction the corpuscular theory, though severely shaken, managed to hold its ground for the time being.

Early in the nineteenth century another and a more serious objection was encountered It was found that two beams of light traveling in the same direction might actually extinguish each other and produce darkness. This finally disposed of the corpuscular theory of light.

The third alternative method of rousing the dog now comes up for consideration. Perhaps light may travel in some such way as sound

The nature of sound is quite well understood It travels through the air somewhat as a train of waves travels in water Light objects floating on the water merely rise and fall as the waves pass, showing that there is no forward motion of the water as a current, but merely a vibratory rise and fall. Only the form of motion moves onward

A somewhat similar vibration takes place when sound passes through air. When the sound wave reaches the ear of the dog it sets the drum of the ear in motion, and this in turn excites a nervous impulse which creates in the brain the sensation of sound

But sound will not pass through a vacuum It is a common lecture experiment to place an electric bell under the receiver of an air pump and exhaust the air The sound of the bell becomes fainter as the exhaustion progresses, and finally ceases to be heard Sound waves require a medium for their transmission, yet light vibrations come to us from the sun across ninety million miles of empty space. Is space as empty as it seems to be?

The phenomena of both gravitation and light lead to the same question: "How can a body act on another across empty space?" The utter inconceivability of action at a distance gave rise to the hypothesis that space was not really empty, but was filled with a medium to which was given the name of the ether.

The properties that had to be assigned to this hypothetical ether to make it fit the facts of observation were not only strange but incompatible with each other. The first difficulty to be met was that such a medium might naturally be expected to cause a retardation in the motion of the heavenly bodies. Such a

retardation in the case of the earth would cause it to spiral gradually inward toward the sun, with an accompanying change in the length of the year. No such retardation has ever been detected

But the earth is perhaps rather a massive body for such a test A much more delicate test is possible in the case of comets, which are largely gaseous in composition, but even here the evidence is negative

To account for the absence of any retarding effect two assumptions were made about the ether; first, that it was absolutely frictionless, and second, that it was tenuous to a degree unparalleled in our experience of material substances.

Such assumptions were logically necessary, but led to a serious contradiction, for if the ether could exert no retarding effect on bodies moving through it, how could it exert the accelerating effect we call gravitation? In other words, the ether had to be "ethereal" to the *n*th degree, and at the same time stronger than a steel cable! And in time it was found necessary to assign to the ether other attributes equally inconsistent As a result, toward the close of the nineteenth century there prevailed an uneasy feeling that we were on the wrong track; that, like Frankenstein, we had invented a monster which was getting out of control Yet to abandon the idea of the ether was to be confronted with the equally inconceivable idea of action at a distance Here was a dilemma, indeed, and what was to be done about it?

In the history of scientific thought it has never happened that we have been long without a theory of some kind when we needed one; and in this dilemma two suggestions were made, one in 1886, by Hinton, whose name is known to but few to-day, and the other in 1916, by Einstein, whose name (at least) is familiar to everybody. It is interesting to note that both these suggestions adopted much the same way out of the difficulty, though in their subsequent development the two theories differed widely

Both Hinton and Einstein recognized the necessity for a space-filling medium of some kind They also saw that its frictionless character must be retained. This left its supposed tenuity as the only possible point of attack The magnitude of the force of gravitation suggests a connecting medium of a rather substantial character, and since there is obviously no room for such a substantial medium in our space as we know it, both Hinton and Einstein placed it where there was plenty of room—out in space of four dimensions

The concept of four-dimensional space was not new even in Hinton's day For at least half a century this idea had had a place in mathematical theory Hinton, however, was a pioneer in its application to physical problems

Charles Howard Hinton was an Englishman, a graduate of Oxford University He spent some years as a professor of mathematics in Japan, after which he came to the United States, and held positions in Princeton University, in the University of Minnesota and in the U S Naval Observatory. It was my privilege to make his acquaintance while he was at Princeton, and to correspond with him until his death in Washington in 1907 He published in 1886 a book called "Scientific Romances," in which is found much of his four-dimensional theory of the ether

Imagine a paper doll between two large sheets of plate glass, both glass and paper being so smooth and highly polished as to be frictionless. Suppose the doll to be conscious, and able to move about in his two-dimensional world All his experience being confined to motion in a plane, he would have no conception of a third dimension. As he moves about he may encounter inanimate pieces of paper of various shapes and sizes, which he calls "matter" He observes that a piece of

such matter if set in motion moves without retardation, and from this he deduces that "space" is "empty."

Now suppose that the glass is tapped strongly at a point some distance away from the doll A wave motion will be set up in the glass, and when this reaches the doll he will feel it, but will be puzzled to explain how this vibration has reached him from its point of origin The space around the doll is empty of matter (*i e*, paper), and how can there be a vibration without something to vibrate?

This contradiction would be hopeless to a two-dimensional intelligence, but we, with our three-dimensional experience, see at once that there is indeed something very substantial to do the vibrating, something which does not lie *in* the doll's space, but *alongside* it, out in three-dimensional space, exposing to the doll's touch only its smooth, frictionless and imperceptible surface.

Now move up one dimension, by analogy, and we have Hinton's theory of the ether A two-dimensional figure, such as a square, is bounded by one-dimensional lines; a three-dimensional figure, such as a cube, is bounded by two-dimensional surfaces; and a four-dimensional figure, similarly, would be bounded by three-dimensional solids And just as the doll's two-dimensional space was in contact at every point with the surface boundary of the solid glass, so our space of three dimensions is in contact everywhere with the solid boundary of the four-dimensional ether

Hinton discusses the question whether this paper doll could in any way become conscious of his spatial limitation, and points out that there is a way by which he might become aware of a third dimension, depending on the fact that the doll actually has a slight thickness in that direction, though he is not conscious of it

A piece of paper between two sheets of glass can turn about an axis perpendicular to itself, but not about an axis in its own plane A circle under these conditions could not turn about its own diameter; but Hinton points out that if the diameter of the circle be very small, less than the distance between the glass plates, it would have perfect freedom of motion, and could then execute the three-dimensional movement of turning about its own diameter

But a circle thus turned looks the same as before, and if anything of this sort were to happen in the doll's experience there would be nothing to suggest to him that anything unusual had taken place. With an unsymmetrical figure the case is different A piece of paper in the shape of a lower-case *p*, confined between two sheets of glass, may be turned into various positions

p d

but can never be made to look like a lower-case *q* To change *p* into *q* requires motion in a third dimension But if the *p* be so small that the width of its loop is less than the distance between the glass plates, this change might be accomplished.

If the doll should discover that bits of paper below a certain critical size could be made to behave in a way which is impossible (or, as he would say, inconceivable) with larger pieces, he would regard this as an important and significant fact; and if he should be led by this to make a microscopic study of these motions he might have revealed to him the existence of a third dimension.

Considerations of this nature led Hinton to the conclusion that the most likely place to look for suggestions of four-dimensional motion would be in the behavior of molecules and atoms, and during a visit which I paid him at Princeton in 1897 he outlined to me several lines of thought in this direction. For instance, consider the law according to which electrically charged particles act on each other Under ordinary conditions we find that the force of attraction

varies inversely as the square of the distance between the particles But if our space had a very small extension in the fourth dimension, and the distance between the particles was less than this extension, there would be geometrical reason to believe that the law of attraction would change to the inverse third power. Hinton also pointed out to me that the change of p into q might have an analogy in the optical behavior of the four kinds of tartaric acid.

Such, in brief, is Hinton's four-dimensional theory of the ether The physical applications that he made of it include the phenomena of light and electricity, but in neither his published writings nor his private communications to me did he deal with gravitation It was left for Einstein, thirty years later, to propose a theory fundamentally much like Hinton's, and apply it successfully to gravitation

Imagine a smooth flat frozen surface of a lake Assuming friction to be absent, a stone set in motion over this surface would move in a straight line with uniform velocity If we observed the path of the stone to depart from a straight line at any point we might reasonably infer that there was a slight elevation or depression of the ice at that place, even though we could not clearly see it from where we were standing Now suppose there to be a large, heavy stone resting on the ice, producing a depression or cusp in the surface in its neighborhood At some distance away, where the ice is again flat, suppose a small stone, which produces no appreciable cusp, is set in motion in such a direction as will carry it past the heavy stone at a short distance from it, well within its cusp The path of the small stone, at first a straight line, will, as it enters the cusp, gradually assume a curved form Assuming no attraction to exist between the large and the small stone, the latter will pass on and out of the cusp, its path again becoming straight, but on account of the brief twist to which it was subjected the latter portion of its path will not be in the same direction as the first. The small stone will have suffered a permanent deflection

An observer watching the motion of the small stone through what we may call Newtonian spectacles, which do not show him the curvature of the ice, will say "Yes, on passing the large stone the small stone seems to have experienced a force of attraction which has deflected it from its straight path" But let him replace these glasses by others of Einsteinian make, and he will say, "No, I see now that there was no force of attraction at all It was purely the inertia of the small stone combined with the curvature of the surface that produced the change in its path"

If the small stone passed very close to the large one it might not be able to get out of the cusp at all, but would circle round and round, like a planet round the sun

This theory of Einstein and that of Hinton are fundamentally similar The motion of the stone over the ice and that of the paper between the sheets of glass are both subject to a constraint which limits their motion to two dimensions But Hinton considered only flat space, while Einstein added the idea of space curvature, which gives rise to an effect which we call gravitation

Applied to the space in which we live, Einstein's theory contemplates a space curvature in a fourth dimension analogous to the curvature of the ice surface in a third dimension Einstein regards our space as normally "flat," but warped or distorted around every lump of matter, large or small. The great mass of the sun produces a space distortion which reaches beyond the

planet Pluto, and captures an occasional comet that happens to come within range

The concept of space curvature, like that of a fourth dimension, to which it is closely linked, is older than either Einstein or Hinton, but had always been confined to the realm of mathematical theory As applied by Einstein to physical problems it has been remarkably fruitful In addition to offering an explanation for gravitation it enabled Einstein to predict two physical phenomena which had never been observed, but which have both been subsequently confirmed by observation One of these was that a star nearly in line with the sun, as seen at the time of a total eclipse, should appear displaced from its true position A ray of light from a star traverses millions of miles of space remote from material bodies, and consequently "flat" In this region the path of the ray is a straight line But close by the sun, whose great mass causes a considerable warp in space, the path of the ray is bent, and when it again becomes straight it has been permanently deflected from its original direction

It is interesting for one who remembers Hinton to compare the reception accorded his ideas with that which has been the guerdon of Einstein. In talking with Hinton's colleagues and students, ten or twelve years after the publication of "Scientific Romances," I found the opinion prevalent that the fourth dimension might be all right in its place as a mathematical theory, but physically – – – ! Only one generation later, when Einstein again brought the fourth dimension into physics, his reward was world-wide fame and a Nobel prize *Tempora mutantur!*

There is much more that might be said about the space in which we live, but perhaps I have said enough to justify my earlier statement that empty space is a greater wonder and a more mysterious puzzle than its visible contents

SCIENCE IN AN UNFRIENDLY WORLD

By Dr. W. JAMES LYONS
NEW ORLEANS, LOUISIANA

THAT there are prevalent in the world to-day certain trends of thought and action unfavorable to the future prosperity of science needs no extensive proof. The sentiments range from a general coolness toward technological advance to an active antipathy toward a free science. Each challenge, separately, has been recognized and identified with more or less adequacy, but a more comprehensive view of them as parts of what is in effect a more general movement is lacking While it may be said that one of the challenges to science merely implies "friendly competition" of a sort, or that another is only a vague rumbling, they deserve a brief consideration by the student of affairs, as well as by the scientist Because they are not isolated in time, but confront science together, their significance is enhanced It is not my intention, however, to "uncover with alarm" an immediate danger or one of appalling magnitude.

These current dangers to science are clearly distinguishable from each other. The first, specifically, is the attack on the dominant positions which science, and the *scientific method* have come to achieve, during the past seventy years, in the national philosophy of education. The most prominent and energetic leader of this thrust is, of course, Robert Maynard Hutchins, of Chicago, whose ideas have been developed in numerous publications and addresses. The second adverse trend, less well-defined, is a growing coolness toward science, and suspicion of it, in the public mind, more markedly at the low-income level The subtle nature of this threat precludes its having any leaders. Aside from some political talk about declaring a legal holiday for invention, the attitude is yet largely negative What well may be taken as the representative attitude in this respect has been presented sympathetically by Norman Foerster[1] Finally, science is confronted with the demoralizing programs of the totalitarian governments The problem for science here is not the cruelties and injustices which have been inflicted on scientific workers in those countries on account of race or religious creed, reprehensible though such activities are. But a problem and a threat to free science does exist in the system of regimentation and delimitation, of thought and inquiry, in vogue in the dictatorships.

These three unfavorable currents, in common, reflect a lessening in the prestige which science has enjoyed for decades. They reflect, it would seem, a conviction spreading vertically and horizontally that science in one or another of its aspects is not as worthwhile to mankind as it had seemed to be. Whether, further than that, any causal or logical relationships between them exists, I am not prepared to say. It does not appear, however, that the existence of such relationship is pertinent to the present discussion.

Bound up with the question of whether scientists are meeting these challenges satisfactorily is the one whether some of the criticisms or attitudes are justified. What has become the traditional mode of pleading the case for science is to point with pride to past achievements and to predict a future of more abundant crea-

[1] "The American State University." Chapel Hill· University of North Carolina Press, 1937.

ture comforts and less pain A latter-day expansion of this theme has been an invitation to the world to put itself in the hands of science for the great cure of all spiritual, economic and social ills Perhaps this proposal is in the nature of a counter-offensive But the whole argument is becoming a little worn and empty It was effective thirty years ago, but is not pertinent to the dominant interest of the troubled world of to-day. Some of its implications have been rather badly riddled by observers of the modern scene.

But what can and ought the apologists of science say or do in its behalf?

I

It is true that the analysis and criticism of Dr. Hutchins and his associates are focussed on the theory and pattern of higher education which the American system had evolved by, say, 1930. Nevertheless, science is greatly implicated, since the dominant theme in that theory was the *scientific method* In the reaction against the indoctrination which characterized earlier practice in higher education, objectivity and the empirical basis of knowledge were now emphasized. Less and less, with the passage of time, was there a willingness to teach anything that could not be rigorously proved. Norms for evaluation and appreciation became themselves subjects for dissection and objective analysis The emphasis turned to equipping the student with a fund of specialized knowledge, and the special techniques by which more facts could be uncovered.

This concept of education the new critics have branded as anti-intellectual. It is claimed that in the modern teaching of science, reason has been suppressed, in deference to the accumulation of an ever-expanding body of facts [2] In consequence, then, of the influence which science, as well as some other factors, has had on education, we are told that the modern college graduate has lost the art of thinking and knowing The factual deposits which have been left by his collegiate sojourn lack integration in any broad sense. He is without general principles and standards according to which he may recognize, understand and evaluate the large variety of problems with which he will be confronted in later life

This case against science, materialism and the elective system in higher education has not been unconvincing. More than one college has hastened to revise its curriculum and, in re-announcing its aims, pay tribute to the *disciplined mind* —a term which a few years ago connoted the extreme of intellectual atrophy. It is the theory of the New Program, says Stringfellow Barr, that "In addition to being able to read, write, and reckon more skillfully and fruitfully than the American college graduate of to-day commonly does, in addition to being able and willing to face present issues, he should be able to recognize those eternal problems which his ancestors faced before him and which recur for every generation of human beings. . . . Experience had taught that the best statements of those problems are the 'classics' of human thought "[3] The variance between the point of view and mode of thought here disclosed, and the modernistic and iconoclastic, scientific attitude is readily apparent

Not unlike the advocates of science in education, the new humanists appeal to the democratic traditions of American society.[4] Only a system of liberal education, embracing the humanities to an

[2] Robert M Hutchins, *International Jour of Ethics*, January, 1934.

[3] *The Key Reporter*, autumn, 1938.

[4] Compare, for instance, Dr Millikan's statement at Reed College, *The Key Reporter*, autumn, 1938, p 5, with those of Dean Marjorie Nicolson and Roscoe Pound in a recent symposium, *The Key Reporter*, summer, 1939, p 1

important degree, it is indicated, can free men's minds, and safeguard their freedom of thought and speech.

None of the new curricula designed for a more humane education appear to have completely eliminated mathematics and the sciences. With varying prominence, these branches of knowledge are given places in the courses of study. Their *purity* is the norm for admittance. But the sciences are under surveillance, if not suspicion No longer, under the new plans, are they to be the pacemakers or patterns for the literature, philosophy and history courses There is a feeling that science as a whole, after sixty or seventy years, has forsaken culture, even civilization.

Scientists and technologists, particularly those associated with education, would do well to recognize that much of the rationale of the new humanist movement is sound. It appears that only by first doing that are they likely to get an attentive audience

It is fairly certain that there has always been a demand, of varying vigor, for a type of education which looks to the development of the whole individual The old *classical* education of a hundred years ago attempted to meet this demand by reducing all graduates to one accepted type, the conservative, respectable, widely but vaguely informed gentleman All facets of the personality were polished, albeit none very brilliantly. But while every educational theory has embraced the idea of well-rounded development, as an ideal at least, the modern, scientifically-inspired higher education has, in practice, avoided the responsibility of itself pursuing that objective. Under the urge to advance and spread impersonal, scientific knowledge, the colleges and universities, their faculties and curricula, have lost sight of the individual personality Thus, while higher education at its best has been producing rather well-equipped scholars and research workers, in so far as it has contributed, the graduates are without any well-formulated objective in life, are unconscious of their moral and social responsibilities, have no confirmed esthetic or cultural appreciations Even the functions which the colleges have been performing well lose much of their attraction when it is realized that but few of their graduates are associated with scholarship or research in later life

The scientist-educator, rather than continuing to proclaim the adequacy of scientific knowledge as the framework of higher education, will render a greater service to society, and to the cause of science ultimately, if he will cooperate in the design of curricula which more effectively meet existing needs Such curricula will aim to realize, within the bounds of each individual's capacity, men of enlarged vision, sensibilities and intellect To accomplish this will require a re-orientation of science education; some "scientistic" dogmas will have to be shed, and some concessions made to the non-scientific branches. There is need for a renewed recognition of the limitations of science, particularly in the fields of human relations and conduct Here the point of view which continually stresses standards of good citizenship and moral responsibility, is more profitable to the average student than is the indifferent, factual and analytical approach, which aims to be *scientific* Many elementary courses employing this approach never get far beyond describing the approach itself, and conclude by leveling all standards and principles The student gains nothing positive.

All too often have advocates of science discounted and disapproved whole sections of the cultural deposit of the race, largely because they were accumulated by non-scientific methods. In many of these fields science is still groping for an effective approach, and has thus far

established only general, abstract principles. Whatever motive is associated with this immature sort of science can not be its own Realism would dictate that here science can not yet offer a workable substitute for the structure which men have built up from experience and expediency, by trial-and-error, hammer-and-tongs methods.

While educators and scientists may wisely make concessions to the non-scientific branches, nothing indicates that all claims for modern science should be relinquished It must be recognized that the physical and biological sciences have made contributions of facts and generalizations about nature, with which, for tangibility and value, the unhampered speculation and magic of earlier ages have nothing to compare. Educators may well take precautions against the current movement leading back to the old type of classical training. This type of education, adapted to an aristocratic society, and accepting ignorant bliss for philosophic calm, has tended to train narrow-minded and snobbish young men and women.

II

The historians of science are responsible, it would appear, for the unpopularity of science among those most acutely affected by the depression In their clamor to enhance the scientific tradition, and hoard for science all credit for the remarkable and unprecedented material advances which studded the century and a quarter preceding 1930, these historians have been more enthusiastic than accurate The steamboat, the locomotive and railroad, the power mill, the telegraph, etc, were all hailed as triumphs of the scientific method. Passing over the inaccurate and illusory nature of this interpretation of technical and commercial progress, the fact remains that it achieved wide currency. In the more intellectual circles, technology and the development of new commercial practices were credited with facilitating the adaptation of science But, as the doctrine filtered on down through the schools and the press to become a part of the prevailing thought-pattern, science emerged as the most prominent force responsible for making this modern world so startlingly different from all preceding ages. Thus when, for many people, the modern world, in spite of all its resources, began to slip from its role of "best of all imaginable worlds," science came in for a proportionate share of blame

Had a more accurate picture of the part science has played been presented, science would not now be the object of so much suspicion and resentment

It is true that the modern world is a product of science, but it is also a product of the commercial and industrial expansion which seems to have had its inception in the city-states of northern Italy about the fifteenth century Only by distorting the meaning of science to be synonymous with all types of initiative and daring having an intellectual content, can this expansion be regarded as a phase of scientific activity. This economic expansion and the rise of scientific inquiry are more properly to be interpreted as separate aspects of the more general cultural renaissance.

It is true that, in technology, industry and science have cooperated to a large extent But for *pure* science, facts and laws have their gradations of importance regardless of whether or not they have immediate application. The criteria here are the fundamental nature of the facts, and the generality of the laws, as they bear on a fuller understanding of nature. Admittedly, the scientist, in mapping out his programs of research, is not always oblivious of the ultimate utility of his possible findings. But his immediate, and primary objective is to uncover more elements of behavior in

nature, and to correlate these elements under a general principle or theory.

The inventor or technologist, on the other hand, is not concerned with facts, old or new, which do not contribute directly to the perfection of the device or method upon which he is working It may be said that, in general, it is only the technique of experimentation that the inventor has in common with the scientist. Many early inventors not merely ignored, but actually defied, the accepted scientific doctrines of their time, and evidently with success

Still another agency, distinct from either science or invention, has contributed to the material comfort and convenience of modern life. It is the spirit of initiative and adventure without which, though we still had our science, the world would be very different It is this spirit which has thrown great bridges across rivers, railroads across continents, airways and cables across oceans, given us by mass production, automobiles, electric refrigerators, radio receivers and the host of other accessories of present-day life. It is this same spirit which leads to competition and friction between groups of people, within borders and across borders

Thus, a more comprehensive view discloses that science was not the main spring in the development of our modern material facilities, but rather, one of several contributing factors. The role of science was passive, it made available facts and laws which men of action in time saw fit to exploit advantageously Condemnation of science for the present social and economic derangement of the world is as unwarranted as was the undivided credit it received in earlier, more prosperous decades.

III

What attitude scientists are to adopt toward those political régimes which are unfavorable, if not outright antagonistic, to scientific progress, already appears to have become a matter for debate.[5] At the outset of any discussion of this type it should be emphasized that scientific groups have no business taking up the torch for any political or religious "ideologies," however attractive some of these, or abhorrent others, may be to the individual scientist personally.

Those of us adhering to the liberal tradition should like to identify pure science with democracy on the theory that, in the realm of ideas, science stands, as does democracy in the social domain, against authoritarianism. We note that in both modern science and ideal democracy, the statement or conclusion of no man is beyond criticism or scrutiny, that in science a great principle is never irrevocably established, but is accepted only in so far as it is in accord with a wide array of experimental facts, just as in a republic, a government and its laws exist only so long as they are in accord with the will of the popular majority But, however attractive this analogy may appear, as with all analogies, it can not be pushed too far, to be confused with an identity. That the positions of science and democracy are merely analogous, and that the two not always have been even allies and sole mutual supporters, is indicated by the disinterested prospect of history. We have only to recall the brilliant researches of the French mathematical physicists of the eighteenth century, whose work was supported by the aristocracy of a decaying despotism Again, no one can say that pure science did not thrive in imperial Germany. On the other hand, we recall that the first truly popular, democratic movement in Europe found "no use for scientists," and forthwith beheaded the father of modern chemistry.

[5] The principle involved here has been analyzed by D. C. Smith, *American Scholar*, autumn, 1937.

Science can not endorse this or that ideology, or social system simply because, as has been often pointed out, science can not choose between objectives or ultimate values. Any such an alignment is artificial It does not appear, however, that scientists must remain oblivious of current social and political developments having implications in the activities of science

Science has a job to do: to enlarge man's knowledge of nature and of the world in which he lives The materials of science are facts Its method is not to stop at arbitrarily established boundaries, if beyond may lie truths to be uncovered and examined And because this method is of the essence of modern scientific inquiry, scientists have the right to insist that the integrity of the method be preserved. The public proscription by scientific organizations of those agencies or régimes which endeavor, by coercion, if not by law, to circumscribe the activities of science, to supplant objective data with propaganda, or to circulate flimsy, immature opinion as scientific doctrine, can not be declared inappropriate Thus, the recent indictment by a group of American anthropologists of the National Socialist doctrine of "Aryan" supremacy, as having no factual basis, was a commendable move.

In general, toward recent ideological developments the attitudes of scientists thus far appear to be divided Some scientific workers are inclined to remain aloof and complacent, concerning themselves with the solution of their immediate technical problems Their view, evidently, is that the infringement on free inquiry by political and religious ideologies is not something "new under the sun," and that it has not in the past proved fatal. With that view goes the conviction that the very accomplishments of science make its acceptance and support inevitable The spirit of this group, it would appear, dominates the scientific societies and accounts for the extensive silence of the latter in the face of current developments

Scientists of another temper, alarmed at the prospect of a worldwide censorship of research and inquiry, and being unable to register their apprehension and disapproval as a scientific body, have aligned themselves with pro-liberal organizations whose objectivity is questionable Neither one of these courses is highly effective in preserving a progressive, untrammelled science, free from potentially discrediting alliances

While the sense of the complacent scientist may be justified, I propose that he re-examine his premises, bearing in mind that earlier successful cultures, becoming assured and complacent, have been supplanted And not always has the new order been superior; one civilization at least, that of Rome, disappeared in the darkest barbarism. It is not advocated that scientists organize to entrench modern science as an established system, simply for the sake of self-perpetuation. Indeed, if it is conceivable that some method of inquiry other than the one we now know as the *scientific,* could more readily give man an accurate picture of his world, scientists should be the first to welcome the method The real problem is the preservation of a proven method of inquiry against the suppression of all significant inquiry.

THE SOCIAL SIGNIFICANCE OF SCIENCE

By HENRY M. WRISTON

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There is no question whatever that the advance of science has the deepest social significance; it is manifested dramatically in the triumphs of medicine, in the triumphs of the battlefield and in the triumphs of plenty through an economy of abundance. But I need not, in this tragic hour, remind you that each song of triumph has its antiphonal song of despair For science is being used to destroy more men than the science of medicine can save, and triumph in war is defeat both for victor and for vanquished Even as men fight for victory they know the losses will be awful. The economics of plenty subsists in a world where politics decrees an economics of scarcity In fact, political forces have overcome scientific forces until millions of men are unemployed, plenty is burdened with taxes for the support of scarcity, and abundance is destroyed for the sake of power "Guns before butter" is only the most conspicuous illustration. Meanwhile medicine is used to heal the artificial wounds by which we supplement the ravages of nature.

Under ordinary circumstances the call for an interpretation of the social significance of science might be taken as a somewhat wishful, not to say nebulous, observation. At the moment, however, there is a hard reality which gives it point The university, the home of pure science, and industry, the home of applied science, have both been hard hit The partial devaluation of the dollar, which operates over the long pull substantially as a capital levy, and the artificially low interest rates produced by political manipulation of credit for the benefit of perpetually unbalanced governmental budgets are two of many adverse influences In Germany inflation was carried so far that endowments were wiped out, and science, already too heavily controlled by the government, was thrown entirely into the hands of the state The universities of England to-day face the fact that they are virtually mobilized for war purposes; they are in the hands of the state If the war be long and costly, as it appears likely to be, then their independent resources will be impaired or destroyed The state may not be willing to allow them the freedom they have heretofore enjoyed, because social pressure for immediate utilities and services will run adversely to the support of pure science Without pure science as its refreshing well-spring, applied science must soon suffer.

Whether the United States stays out of the war or goes into the war, this nation will be impoverished The profits of neutrality in modern war are illusory Even if we remain neutral, the costs of armament in the United States will mount beyond all previous expectations; the costs of living will go up; our currency may come to be, in the technical phrase, "overvalued" with reference to the currency of warring nations, our debts will be so large that the government will not want to pay them It is the characteristic history of government debts, just as of private debts, that when they are too large they are not paid. Witness the German reparations, witness the inter-allied debts, and, if you please, witness the devaluation of the American dollar. If our currency is overvalued in that technical sense and if the debt

gets too large, it means a further devaluation of the dollar, a further capital levy, that is to say, upon endowed funds and upon industry. That, of course, would involve a corresponding dependence of pure science upon the state, and a further diminution of corporate profits resulting in restricted budgets for applied science The necessity, therefore, of an acute awareness of the social implications of science, of the impact of science upon social organization and the social future is instant and immediate, not only for the benefit of society as a whole, but for the benefit of science itself

In Washington the Senate has been engaged in a widely advertised debate upon neutrality Like most discussions it wandered from the real issue to deal with many other points Certainly the disputants had security more actively in mind than neutrality But the neutrality of politics is always imperfect at best, while the neutrality of science is absolute Science made possible the conquest of the air, but that conquest can be used for carrying bombs or for carrying the mails Science with even hand provides poison gas and the means to defeat it. Science impartially devises high explosives and the armor to resist them Science provides the instruments to wound men and to cure them In the great warfare between good and evil, therefore, science is of necessity neutral, but it is not necessary that the scientist be neutral The chemicals, the energies, the instrumentalities of science must be oblivious to values, but the men who employ them can not be, for scientists must be men before they can be scientists, and their humanity must be greater than their skill

The other day I was visited by a man who has had a distinguished record in one of the fields of engineering and also as a political and diplomatic adviser. He was lamenting the fact that in the universities it was almost impossible to find a man dealing with the great problems of international relations who had any understanding whatever of the impact of science and technology upon the life of the world, who had any conception at all of the importance of science to our outlook upon individual life and death and our view-point upon national political and economic life. He went on equally to lament that among scientists there was a similar want of understanding of the social significance of their own labors and of the rôle which their skills might play in the reorientation of international affairs.

Research has achieved many of its distinctive triumphs at the cost of loss of perspective, men of learning have rent the seamless fabric of life in order that each might fashion his own banners. However gaily those banners may flash in the sunshine and however proudly they may be carried at the head of triumphant advances, we may be reminded in the current tragedy of the world that such triumphs can be hollow. The achievements can be rendered nugatory The advances may be halted Indeed, we may be thrown back into black darkness unless men of science understand the social significance of their work and are activated by the warm emotions of the humanities, unless those who give their lives to the study of society are ready also to take full cognizance of scientific progress, and unless the philosopher whose duty it is to embrace all knowledge and to bring it into coherence and significance can unite with the scientist and the social student in this major enterprise of common understanding

There have been fantastic proposals for various "courts of wisdom" composed of leading men in the several fields. At the moment they would have no effective means of talking with each other, since they do not understand each other's language. Consequently, these would be

courts of foolishness rather than of wisdom, for they would have to seek the greatest common divisor in their intercourse, and that common divisor would be pitifully small The one solution is synthesis, and synthesis can occur only in the mind of one man at a time If anything like the same portion of energy were turned toward this synthesis as was put into the attempt to find an equation which united matter and motion, time and space, we should have results, if not as startling, at least as useful and promising.

MEDICINE IN THE BIBLE*

By Dr. CHARLES WEISS

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THE Bible has been variously regarded as a text-book of theology, a source book of sermons and a reference book of early Jewish and Christian church history But no one can overlook the fact that it is a great work of literature, a document full of vital and varied human interest To those who are interested in preventive medicine and hygiene, it affords entertaining reading As we browse through its pages, we are struck by the fact that the one person who must be regarded as the founder of this science is none other than Moses Stripped of the mythology and legends which surround his life, Moses still stands out as a colossal personality, a brilliant legislator, an inspired and inspiring teacher, a righteous judge, an able executive and an efficient sanitarian It was he who organized the first department of health in the history of the world

While it is possible that Moses learned his medical lore from the Egyptians, it is nevertheless conceded that he synthesized this knowledge into a philosophy of life and into a religion He advanced the practice of personal and public hygiene, not as a taboo, but by appealing to the religious emotions and to a sense of the nobility of life. To quote Leviticus 19· 2, "Ye shall be holy, for I the Lord, your God, am holy " Likewise in Deuteronomy 23· 15, we read, "for the Lord thy God walketh in the midst of thy camp,—therefore shall thy camp be holy, that He see no unseemly thing in thee, and turn away from thee " Freedom from disease was the reward offered in return for obedience to the will of God "If thou wilt diligently hearken to the voice of the Lord thy God, and wilt do that which is right in His eyes, and wilt give ear to His commandments, and keep all His statutes, I will put none of the diseases upon thee, which I have put upon the Egyptians for I am the Lord that healeth thee "[1]

In order to appreciate the full significance of the hygienic laws of Moses, it must be recalled that he was leading a people just liberated from Egyptian bondage, through a great wilderness, a desert land devoid of all sanitary facilities This undisciplined army had to be maintained in good physical, mental and spiritual health. To begin with, there was the task of providing potable drinking water and wholesome food. This meant provision for the disposal of refuse and excreta, of dead human and animal bodies and the development of a system of control of communicable diseases Any one familiar with military science and tactics knows that even to-

* Address delivered at Stanford University (Bible Exhibit Dep't of Classics) April 14, 1937, and in the Hall of Religion, Golden Gate International Exhibit, June, 1939.

[1] Exodus 15: 26.

day this is a gigantic task, both during war and peace.

Let us see how Moses accomplished this. First, he protected the water supply. "This is the law. when a man dieth in a tent, everyone that cometh into the tent, and everything that is in the tent, shall be unclean seven days. And every open vessel, which hath no covering close-bound upon it, is unclean "[2] When a diseased animal fell into an open vessel, it was considered unclean and unfit for use Hence we read in Leviticus 11 33, 'And every earthen vessel, whereinto any of them (dead animals) falleth, whatsoever is in it shall be unclean, and it ye shall break " By preventing contamination of drinking water, many intestinal diseases were avoided Among these are typhoid fever as well as bacillary and amoebic dysentery

When we recall the absence of facilities for refrigeration and sterilization of food during Biblical times, we must regard the dietary laws instituted by Moses as nothing less than life-saving Many of the land and water creatures whose food he prohibited were either commonly infected or subject to infestation Animals known to be diseased were forbidden as food An animal which had been partly devoured by another was "unclean " Such animals may have become infected with rabies or hydrophobia The pig is frequently infested with flukes, trichina or with pork tapeworm. Rabbits may be infected with a disease known as tularemia Shell fish are frequently contaminated with human sewage and typhoid bacilli. Schistosomiasis is carried by some species of snails Wild animals often die of plague or tuberculosis. All these were placed on the forbidden list, thus avoiding epidemics of food infection and food poisoning.

Another remarkable chapter in the sanitary code of Moses deals with the disposal of human refuse. We read in Deuteronomy 23: 13 and 14, "Thou shalt have a place also without the camp, whither thou shalt go forth abroad. And thou shalt have a paddle among thy weapons, and it shall be, when thou sittest down abroad, thou shalt dig therewith, and shalt turn back and cover that which cometh from thee " The late Major O'Connor, who was with the British army when General Allenby entered victoriously into Palestine, informed me that this is essentially the method used by the British soldiers during the recent World War Its effect was to prevent infestation of soil and water with hook-worm and schistosomiasis,—Bilharziosis, a disease known to the ancient Egyptians, and still common to-day in tropical and semi-tropical countries

When one reads in the pages of European history that as late as the seventeenth century creams, perfumes and powders were used in the place of bathing, the value of the ritual baths, mentioned in the Bible, may be more fully appreciated There were so many instances when a person had to take a bath or wash his hands for religious reasons that the practice became very common. Thus in Leviticus and Numbers we find the following regulations regarding bathing· (1) Any person who came in contact with the body of, or with the articles of furniture used by, a person having an unclean issue (venereal disease), or with any article used by him was obliged to wash his body and his garments.[3] Washing of clothes was required after touching the carcass of a beast that had died of a natural death[4] (2) Bathing was required after sexual intercourse[5] or after touching a woman who was menstruating Whoever had come in contact with a corpse or a grave was unclean and

[2] Leviticus 11: 32; Numbers 19: 14 and 16.

[3] Leviticus 15: 5–10.

[4] Leviticus 11 25 and 40.

[5] Leviticus 15· 18 and Second Samuel 11: 4.

had to bathe[6] When a "leper" was "healed" of his leprosy, he shaved off his hair, washed his clothing and bathed his body in water[7] The following reference in the New Testament is of interest in this connection, "For the Pharisees, and all the Jews, except they wash their hands oft, eat not, holding the tradition of the elders"[8]

The efficacy of mineral baths is recorded in the Bible The saline waters of the Jordan, the pool of Siloam, as well as the waters of the Bethesda, became famous for their healing powers

While we do not wish to suggest that Moses had any knowledge of bacteria or parasites, he must have arrived, intuitively or empirically, at the mode of spread of contagious diseases For after the war with Midianites, he commanded, "whosoever hath touched any slain, purify yourselves on the third day and on the seventh day, ye and your captives And as to every garment, and all that is made of skin, and all work of goat's hair, and all things made of wood, ye shall purify." "Howbeit the gold, and the silver, the brass, the iron, the tin, and the lead, everything that may abide the fire, ye shall make to go through the fire, and it shall be clean, and all that abideth not the fire ye shall make to go through the water" "And ye shall wash your clothes on the seventh day, and ye shall be clean, and afterward ye may come into the camp"[9]

One of the most remarkable public health procedures given by Moses related to the isolation of persons infected with communicable diseases This routine applied not only to persons afflicted with a venereal disease (gonorrhea), but to that group of skin infections known in Hebrew as "Zoraath" and loosely translated as "leprosy." It is noteworthy that not only the patient himself was to be quarantined, but even those that had had contact with him. "What man soever of the seed of Aaron is a leper, or hath an issue, he shall not eat of the holy things, until he be clean. And whoso toucheth any one that is unclean by the dead; or from whomsoever the flow of seed goeth out; or whosoever toucheth any swarming thing, whereby he may be made unclean, or a man of whom he may take uncleanness, whatsoever uncleanness he hath; the soul that toucheth any such shall be unclean until the even, and shall not eat of the holy things, unless he bathe his flesh in water. And when the sun is down, he shall be clean, and afterward he may eat the holy things, because it is his bread That which dieth of itself, or is torn of beasts, he shall not eat to defile himself therewith: I am the Lord"[10] "And he that is to be cleansed shall wash his clothes, and shave off all his hair, and bathe himself in water, and he shall be clean, and after that he may come into the camp, but shall dwell outside his tent seven days And it shall be on the seventh day, that he shall shave all his hair off his head and his beard and his eyebrows, even all hair he shall shave off, and he shall wash his clothes, and he shall bathe his flesh in water, and he shall be clean"[11]

One of the most remarkable achievements in the field of preventive medicine and hygiene is the introduction by Moses of a compulsory weekly day of rest (the Sabbath) for *all* the people. It is true that the ancient Babylonian calendar included certain days when the king could not perform certain functions; such as riding in a chariot, using fire or wearing the robes of his kingdom A weekly day of rest for *all the people,* however, is indeed a step forward in democracy, as well as in physical and mental hygiene

[6] Leviticus 11 25 and 40.
[7] Leviticus 22 4 to 6.
[8] St. Mark 7· 3
[9] Numbers 31 19–24.
[10] Leviticus 22· 4–8 inclusive.
[11] Leviticus 14 8 and 9.

The Jewish and Christian peoples were the first to benefit from this Mosaic law.

Medicine and Surgery in Biblical Times

While the Bible is not to be regarded as a text-book of the practice of medicine, nevertheless we may glean from its pages much interesting information in this field. Thus, the art and the science of obstetrics were fairly well developed, as shown by frequent reference to the employment of skilled midwives and to the use of the birth-stool.[12] Various anatomical anomalies are described in connection with the laws governing the priesthood and marriage[13] Priests had to be free from certain defects in order to be permitted to carry on their sacred functions[14] Women were ineligible for marriage for analogous reasons Animals could not be brought to the altar as a sacrifice if they suffered from any one of a variety of pathological conditions

Scattered here and there we find other fragments of medical knowledge Many diseases were known and described Among them are affections of the nervous system, the heart and blood vessels, infections of the eye and skin, tuberculosis of the lungs and of the spine, tumors, hemorrhoids, erysipelas and a variety of fevers and boils[15] Several mental diseases are recorded with great vividness and accuracy Thus, King Saul suffered from recurrent paroxysmal mania (insanity) King Saul was a naturally self-conscious man, easily exalted into ecstasy and tyrannical self-satisfaction. He was possessed of homicidal tendencies, turned against his own son and finally becoming despondent, he met with death by suicide. Nebuchadnezzar suffered for seven years from a type of monomania (mental derangement) which caused him to believe himself to be a beast.

Epilepsy is referred to repeatedly in the Bible. The most accurate description is in the Book of Saint Luke 9: 39 "And, lo, a spirit taketh him, and he suddenly crieth out, and it teareth him that he foameth again, and bruising him hardly, departeth from him"[16]

A variety of "palsies" are mentioned. Some of these may well have been due to infantile paralysis As in Saint Matthew 8 5 and 6, "And when Jesus was entered into Capernaum, there came unto him a centurion, beseeching him, and saying, Lord, my servant lieth at home sick of the palsy, grievously tormented" In Saint Matthew 12 10–23 we read, "And, behold, there was a man which had his hand withered"[17]

A stroke of apoplexy resulting from heart disease is described in I Samuel 25 37 and 38 Nabal, after a hearty supper and somewhat riotous night, was stricken with apoplexy and died ten days later As stated, "His heart died within him, and he became as a stone And it came to pass about ten days after, that the Lord smote Nabal, that he died."

It is probable that the so-called Biblical "canker" is identical with the modern word cancer Thus we find in Second Timothy 2· 16, "And their word will eat as doth a canker."

A number of infectious diseases are mentioned Among them are gonorrhoea and what is probably bubonic plague (the burning boil)[18] This may possibly be the so-called "Damascus boil," a form of leishmaniasis In Deuteronomy 28· 22 we have reference to fevers which are probably of malarial origin and to consumption which may be identical with pulmonary tuberculosis "The Lord shall smite thee with a consumption, and

12 Exodus 1. 16.

13 Deuteronomy 23 2

14 Leviticus 21 18–21

15 Deuteronomy 28· 15, 22, 27 and 28

16 See also St Matthew 17 14–18.

17 See also The Acts 9. 33–34

18 Leviticus 13. 23

with a fever, and with an inflammation, and with an extreme burning, and with the sword, and with blasting, and with mildew; and they shall pursue thee until thou perish." Evidence of a knowledge of tuberculosis of the bone is suggested by the law that a priest who had contracted spinal caries could not minister in the sanctuary.

As is still true in the Orient of to-day, diseases of the eye were especially prevalent in Biblical times. We read in Genesis 29 17, "And Leah's eyes were weak, but Rachel was of beautiful form and fair to look upon." Scholars have concluded that Leah suffered from trachoma, which led to continuous weeping

At the head of the list of surgical procedures mentioned in the Bible is circumcision,—a ritual which has survived among the Jewish people unto this day.[19] The prophylactic value of this operation may be deduced from a recent article in the London *Lancet* by Dr Wolbart He points out that cancer of the male organ constitutes 2 to 3 per cent of all types of this disease in man. In the Far East it rises to about 15 per cent. A careful examination of 205 American hospitals by six individual observers showed that of 1103 cases of cancer of the male organ, there was not a single Jew. Likewise 26 Jewish hospitals did not report a single case in a Jew Jews circumcised during infancy (usually on the eighth day) do not develop cancer. Cancer of the penis does occur rarely in Mohammedans who practice ritual circumcision between the fourth and ninth year According to an editorial in the *Lancet*,[20] the annual mortality from this type of cancer in the United States is about 225 Most of these can be prevented by circumcision in early life

Circumcision was not the only operation practiced in Biblical times A number of surgical instruments are mentioned, including sharp cutting stones, knives and awls. The Book of Ezekiel, 30: 21, refers to the use of a roller bandage to mend a broken limb, "Son of man, I have broken the arm of the Pharaoh, king of Egypt; and, lo, it hath not been bound up to be healed, to put a roller, that it be bound up and wax strong, that it hold the sword."

From casual references we conclude that the pharmacist, or apothecary, was well established in his profession in Biblical times Thus in Ecclesiastes 10: 1, we find, "Dead flies make the ointment of the perfumer fetid and putrid; so doth a little folly outweigh wisdom and honour" Mention is also made of the merchant in powders, which shows that medicines had become important articles of trade[21] Among the medicines employed were the balm of Gilead, myrrh, cinnamon, cassia, aloes, calamus, camphor, mandrake and stikenard Oil and wine were also poured upon wounds, as in the story of the good Samaritan

Music as a form of treatment for those afflicted with mental disease is described in Samuel 16. 14 and 23, "Now the spirit of the Lord had departed from Saul, and an evil spirit from the Lord terrified him." "And it came to pass, when the evil spirit from God was upon Saul, that David took the harp, and played with his hand; so Saul found relief, and it was well with him, and the evil spirit departed from him"

Among the ancient Israelites, unlike other primitive peoples, the priests did not monopolize the art and science of healing. Moses assigned to them only the task of supervision in cases of contagious diseases The Bible does not mention a single instance of a priest having performed the function of a physician The prophets, however, practiced occasionally the art of healing. Thus, Elijah brought to life a child apparently

[19] Exodus 4· 25.
[20] *Lancet*, 1· 39, 1927.
[21] Song of Songs 3: 6

dead.[22] His disciple Elisha performed a similar miraculous cure.[23] A man of God restored the paralyzed hand of King Jeroboam[24] Isaiah cured King Hezekiah of an inflammation by applying a poultice made of figs[25] "In those days was Hezekiah sick unto death. And Isaiah the prophet the son of Amoz came to him and said unto him. Set thy house in order; for thou shalt die, and not live." "And Isaiah said· 'Take a cake of figs.' And they took and laid it on the boil, and he recovered"

In the New Testament we have repeated reference to Saint Luke, "the beloved physician" who practiced at Antioch[26] The medicine practiced by St. Luke was, no doubt, influenced by the contemporary Greek civilization.

When we come down to the time of the Apocrypha, we find an increased regard for the distinct profession of medicine.

[22] I Kings 17. 17–22.
[23] II Kings 4· 18 and 34–55
[24] I Kings 13. 4–6
[25] II Kings 20 1 and 7
[26] Colossians 4: 14.

Thus we read in II Chronicles 16· 12, "And in the thirty and ninth year of his reign Asa was diseased in his feet; his disease was exceedingly great; yet in his disease he sought not to the Lord, but to the physicians"

In Ecclesiasticus there is repeated mention of the physician In chapter 38 we find the following famous quotation (The Wisdom of Jesus the Son of Sirach), "Honor a physician with the honor due unto him, for the uses which ye may have of him, for the Lord hath created him. For of the most High cometh healing and he shall receive honor of the King The skill of the physician shall lift up his head: And in the sight of great men he shall be in admiration The Lord hath created medicine out of the earth, and he that is wise will not abhor them."

"Give place to the physician for the Lord hath created him. Let him not go from thee, for thou hast need of him. There is a time when in their hand there is good success"

BOOKS ON SCIENCE FOR LAYMEN

SOME PIONEER PSYCHOLOGISTS[1]

If any one doubts the existence of a wide-spread interest in the topic of the "mind," let him glance over the array of brightly colored "pulp" magazines on the corner news-stand and note with amazement the large number dealing (allegedly) with psychology and cognate topics To be sure, they are filled largely with twaddle or worse, but they sell, and that is all the publishers ask This is merely a roundabout way of saying that many people are interested in mental phenomena, their nature and laws Most readers of this journal, too, are interested in knowing something of the development of sciences and of the men who brought about advances in scientific thought We sometimes forget that advances, whether in science or government or any other field of human endeavor, do not "just happen" or take place automatically; they are due, rather, to the genius or keen observation or hard work of men and women, people who have built additions to a superstructure erected upon the foundations laid by those thinkers who have gone before

In this volume we have a sprightly account of the lives of men who have added to the sum total of human knowledge regarding mental functioning and the care of the mentally disordered. Mr Winkler is a competent biographer, who writes in a highly entertaining, though far from lurid, manner; Dr Bromberg, the author of "The Mind of Man," is an able psychiatrist who is not only a careful student but is himself possessed of a pleasing literary style Thus we have presented readable and accurate biographical sketches of about twenty men who have made valuable contributions to the study of the mind We find presented unfamiliar and familiar facts of the life and work of such men as Gall, the phrenologist, an unwitting founder of the science of neurology; Mesmer, who emphasized the value of suggestion in psychotherapy; Pinel, who struck the shackles from the unfortunate inmates of the Bicêtre and thus established non-restraint as a principle in the care of the mentally ill, Galton, the founder of biometrics; William James and G Stanley Hall, the fathers of psychology in America, Watson, the behaviorist, Terman, the psychometrician; Beers, the founder of the mental hygiene movement; Adolf Meyer, the dean of American psychiatrists, J McKeen Cattell, the founder not only of *Science* but of experimental psychology in this country, and Freud, who will probably go down in history as the greatest giant of them all

The book is heartily recommended to all who are interested in psychiatry and psychology; to those who have an intelligent interest in the care of the mentally ill; to those who rejoice in the accomplishments of original thinkers, in short, to all who boast of a functioning fore-brain.

WINFRED OVERHOLSER, M D

[1] *Mind Explorers.* By John K. Winkler and Walter Bromberg, M D. 378 pp. $3 00. Reynal and Hitchcock. 1939.

FROM THE DAWN OF SURGERY[1]

The story of surgery and of surgeons is a brilliant and fascinating tale of human progress in a field beset by obstacles and inertia of precedent, obstinacy and prejudice born of ignorance. Hiding behind the nom de plume of "Harvey Graham," a prominent British physician feels free to tell his story without cumbersome documentation, dates and footnotes and to interpose his own critical evaluations of men, manner and thought The style is admirable, and the author obviously has a wide and accurate knowledge of his subject From early

[1] *The Story of Surgery* By Harvey Graham. Illustrated xv + 425 pp. $3 00 Doubleday, Doran and Company, Inc. 1939.

demonology, tribal ritual and witchcraft to modern surgery, the story unfolds itself by excellent biographic pictures of the great men who carried forward the torch of scientific reason and logic Asklepios, Hippocrates, Galen, Paré, Harvey, Liston, Syme, Lister and many more There is a disproportionate emphasis of British contributors to progress, but the charm of these word pictures so far exceeds the usual biographic sketches in more "formal" histories that one forgives the unilateral view-point

The author's personal comments and philosophy are absorbingly stimulating One reads for pleasure, becomes absorbed and suddenly realizes how much understanding one has acquired en route In discussing the dim dawn of surgery in certain tribal customs, "Graham" comments as follows "The origin of even the most primitive operation lies in reason The reason may be inaccurate, but there always is a reason" One pauses to re-examine some of our own scientific concepts

This is a volume which should and will interest the layman even more than the physician or surgeon Devoid of technicalities and written in a lively personal style, it is an accurate history of surgery and of its sociologic implications from the Stone Age to the present day Viewed in this perspective, the forecast of the future of surgery is provocatively stimulating

EDWARD J STIEGLITZ

TO FIND A SNAKE[1]

THIS is a simplified handbook for the identification of the snakes to be found in the United States, east of the Rocky Mountains When the authors of a book of this type have a systematic knowledge of their subject, they have a more difficult task in the simplification of their subject than with straight scientific writing Translation of such a subject to the terms that may be clearly understood by the layman is always done with a feeling that much is being left out, but this book represents an excellent job of what can be done along these lines

In the first place, the authors have taken the continental map east of the Rockies and divided it into six areas It is explained in a caption of a full-page map so divided "The first step in the identification of any snake is to determine the Area in which it was found Then look it up in the Key, under the proper Area number"

The "Identification Key" is of an entirely original character, as keys appear nowadays—and some are of bewildering complexity This is the simplest kind of key, but that does not mean that it was easy to prepare This reviewer will wager that the authors of the handbook spent more time and thought in the simplification of the key than one with many indentures or cross references by numbers The key forms a separate chapter of seven pages, based upon continental areas designated by numbers for cross-reference to a map, with subdivisions as to scales being smooth or keeled and the anal plate single or divided Within the subdivisions are lists of the species, with brief annotations as to pattern and reference to page description and plate number if the species is illustrated

Descriptions are satisfactorily presented and the strictly up-to-date nomenclature shows all care in the consideration of various forms appearing in the latest formal lists, which have been undergoing considerable changes Descriptions are accompanied by readable outlines of habits

RAYMOND L DITMARS

IN THE TIDAL ZONES[1]

THIS book is intended to be equally useful to both the scientist and the lay-

[1] *What Snake is That?* By Roger Conant and William Bridges 163 pages 108 drawings $2 D Appleton Century Company 1939

[1] *Between Pacific Tides* By Edward F Ricketts and Jack Calvin. $6 00 320 pp, 112 figs, 46 plates Stanford University Press 1939

man. Because the order in which the animals are listed is according to habitat, and since both the binomial and common names have been used, the authors have met with a high degree of success in attaining their objective As the senior author has had many years of experience in collecting, the animals have been well chosen with regard to their abundance One will seldom find an animal of the tidal zones which has not been included in the book

An appendix listing the binomial of all the animals included in the book, and arranged according to phyla, classes and orders, will be found on pp 257–302 Immediately following each binomial within this list the authors have given references to papers dealing with each particular animal; and they have also included a general bibliography on pp 302–306 The entire bibliography lists some four hundred references

The arrangement of the book is unique in that it is divided into four main divisions which refer to particular habitats, namely. 1, "Protected Outer Coast", 2, "Open Coast", 3, "Bay and Estuary", and 4, "Wharf Piling" These regions are again subdivided For example, the "Protected Outer Coast" is divided into "Rocky Shores" and "Sandy Beaches," and these in turn are divided into four zones "Upper," "High Tide," "Mid Tide" and "Low Tide" The advantages of such a plan are readily evident If one wishes to look for a certain animal or animals, reference to the appendix and then to that part of the book dealing with the region one expects to visit will supply one with the necessary information From the other point of view, if one has been collecting and wishes to classify his catch, reference to that part of the book dealing with the habitat visited will supply the desired names Since practically every animal is illustrated either by figure or photograph, the classification is greatly facilitated and made doubly certain of being correct However, a strictly technical classification is outside the scope of such a book, but it can be pursued through reference to the bibliography.

An interesting and exceedingly valuable feature of the book is the inclusion of reliable natural history information about each species when such information was available

"Between Pacific Tides" is a well-written, informative treatise on 570 marine animals of the Pacific Coast, together with data on their environment and natural history It well deserves a place on the reference shelf of every educational institution of the Pacific Coast as well as of every zoological library.

G E MacGinitie

A NATION-WIDE INSTITUTION[1]

There appears in the foreword, "These volumes record an effort to see museums as a whole, the institution in different patterns, the work it does, the people who give it life—all in the matrix of society The book is not a manual, but a commentary on the condition, the strengths and weaknesses, and the limitations and opportunities of museums

"In sketching familiar conditions, I have gone beyond recounting briefly what everybody knows by saying what I think about what everybody knows Parts One and Two hew close to the line in locating, counting, measuring, and describing the museums of the country Part Three—on museum work—allows some latitude to the reporter, and here the larger institutions get most attention because they are most active "

[1] *The Museum in America* By Laurence Vail Coleman $7 50 Three volumes viii + 218 pp, xiii + 428 pp, xviii + 730 pp Illustrated American Association of Museums, Washington, D C 1939

The author has visited nearly all the museums in America, and seemingly he has studied all the historical data. The historical and statistical facts have been well digested and well arranged, and the writing should be attractive to those who have professional interest in the museum.

Of the public museums, 224 are of art, 358 of history, 60 are general museums, 8 are of "industry and the like," and 72 of science

This review will concern itself mainly with the last two groups The Museums of Science and Industry in New York and Chicago and the Franklin Museum in Philadelphia receive major treatment The author objects to the name "Science and Industry" To quote "The worst trouble about the term 'science and industry' is its implication that two fields are covered Science has come to mean pure science Although pure science is not in the province of industry museums as a rule, there are a few exhibits on the principle of science by way of introduction to exhibits showing how they are applied Also, they are not much concerned with the increase of knowledge through investigation They project no research functions like those of other museums To take up this work would be to back away from the social aim and to approach industrial services in the realm of invention and management"

This type of museum is relatively new, and it is therefore about as futile to predict its character as it is for an uncle or even a father to predict the outcome of a child Not long ago the president of a great university stated that one of his institutions would not do research work because it was written in the code Nevertheless, the institution is doing research work Pure science is basic to modern industry It is unthinkable that the museum can rise to broad esteem without depicting pure science Seemingly the author is unaware that such depiction is already in process. Just as universities learned that research was vital, even so these new museums must and do recognize that the search for new knowledge is as important as proper display

The author, however, does recognize the places of research in museums such as the Field Museum and the American Museum of Natural History It is only fair to quote him "Like institutions of higher education, museums are likely to be as deep or as shallow in their teaching as they are strong or weak in research Where there is no spirit of inquiry, there can be but limited learning since the scholar is a product of the habit of investigation Where teaching goes on unrefreshed by learning, it soon becomes uninformed and even sooner dull But the present danger in most places is from too little, not too much, research work" These expressions make it the more incomprehensible that the author fails to recognize the essential place of research in the museums of science and industry

Thus in expressing his views about "what everybody knows" the author has set himself as a philosopher, but in so doing has in some cases already notably erred by using wrong postulates, inaccurate or superficial observation, and illogical deductions He has implied that attendance records are not a basis for measuring the effectiveness of a public museum as an education institution It would seem to the reviewer that in the long run, attendance multiplied by visitors' capability factor is the only safe basis for estimating effectiveness On this basis published researches, books, magazine and news articles, lectures, as well as comprehensive exhibits, will be reflected in the number and quality of the visitors

F C Brown

E O LAWRENCE

THE PROGRESS OF SCIENCE

NOBEL PRIZE AWARD IN PHYSICS FOR 1939 TO E. O. LAWRENCE

DURING the past twenty years five Americans have been recipients of the Nobel prize in physics, while during the first half of the period for which these awards have been made, only one, Professor A A Michelson, was so distinguished This is another evidence of the remarkable development of physics in this country since the World War Sometimes considered to be part of the aftermath of that war, sometimes associated with the establishment of the National Research Fellowships in physics, this transformation of American physics from an offshoot of European science to a position of independence and leadership has been gratifying to all those concerned in it

The latest recipient of this high distinction is Professor Ernest O Lawrence, of the University of California Born in South Dakota, his formal education obtained in American universities, he serves as a representative example of an American physicist His leadership in the field of nuclear physics has been recognized all over the world since his development of the cyclotron has made the Radiation Laboratory at Berkeley the Mecca of those engaged in this type of work

Achievements in atomic and nuclear physics have been made possible through the development of methods for producing large concentrations of energy For the production of x-rays this is done by accelerating electrons through potential differences of from ten thousand to a million volts Since one electron is very small, it can deliver all this energy to a small part of one atom and so produce the intense local disturbance that results in the emission of x-rays For the disruption of an atomic nucleus still higher concentration is necessary, and it can be produced by accelerating protons, deuterons or alpha particles through large potential differences However, the production and control of large potential differences are very difficult There are troublesome problems of insulation, and the corona losses are so dependent upon weather conditions that the most satisfactory devices are enclosed in tanks A much more convenient method of giving a great deal of energy to a small particle is to subject it to a series of impulses of moderate size It is in just such a way that an automobile engine operates A series of explosions, one after the other and occurring at just the correct times, serves to produce a high speed in the flywheel, while an attempt to use a single tremendous explosion, such as takes place in a large naval gun, would be accompanied by a variety of difficulties

In pursuit of this objective Professor Lawrence and his collaborators built, around 1931, several devices intended to produce high-speed particles One consisted of a long tube containing a number of cylindrical electrodes through which the particles could pass Between adjacent electrodes an alternating potential difference was applied, and by an ingenious arrangement of oscillating circuits it was provided that when a particle passed between a pair of electrodes, the potential difference was in such a direction as to accelerate it When the particle passed through the electrode and out into the space between the next pair, the potential reversed so as to continue accelerating it This apparatus operated successfully and produced mercury ions of large energy, but it was soon largely abandoned in favor of the device that developed into the large cyclotrons in use to-day

In the cyclotron, the alternating potential difference is applied to one pair of electrodes only, but the particle, bent

in a magnetic field, is made to go back and forth between them in such a way that the field is always accelerating it and increasing its speed and energy By this means, with the use of a maximum potential difference of around 150,000 volts, it has been possible to give to particles the same energy as though a total of 18 million volts had been available for acceleration

The enormous possibilities opened up in the field of nuclear physics by the development of the cyclotron have been universally recognized In institutions all over the world, and with a particularly high "density" over the United States, cyclotrons have been built and put into operation, and more are under construction The various instruments at Berkeley have turned out a steady stream of results of importance in the understanding of the structure of atomic nuclei, as well as a variety of products of importance in biological and medical research It has been found that the bombardment of almost any substance with high-speed protons, deuterons or alpha particles, produces from the original element some other element, often in a radioactive state, a state formerly thought to be entirely beyond the reach of artificial influence This provides a tremendous mass of material for the study of radioactive processes and the behavior of the nuclei of the atoms thus produced At the same time these artificially produced radioactive substances have proved of great value as tracers in following the dispersion of various materials through a living organism, as well as in providing a means of getting radioactive radiations really inside the cells of an animal

In the minds of those acquainted with the situation there is no question but that because of the extensive range of its influence on the development of all branches of science, the cyclotron is to be regarded as one of the most important contributions ever made to the technique of modern physics, and that for the ingenuity of its conception and the skill with which the conception has been carried out the highest credit is due to Professor Lawrence

W V HOUSTON
CALIFORNIA INSTITUTE OF TECHNOLOGY

THE CENTENARY OF THE DISCOVERY OF THE VULCANIZATION OF RUBBER

To celebrate the centenary of the discovery of the vulcanization of rubber by Charles Goodyear in 1839, the American Chemical Society dedicated the general program of its Boston meeting, September 11–15, to discussions of vulcanization and to "the real memorial of this great inventor—the great industry which he founded, whose products have been vital to still greater industries, and have contributed to the safety, comfort and prosperity of mankind" In addition, the Rubber Division held a Symposium on the Vulcanization of Rubber and an exhibit of historic treasures and modern products of the rubber industry

In the life stories of Charles Goodyear and his English contemporary, Thomas Hancock, is the description of the small, crude business of the early nineteenth century and its transformation to a huge, modern industry based on their discoveries of methods for processing and vulcanizing rubber When they started their work rubber was a material which promised great things because of its elasticity and resistance to water, but which always failed to fulfil that promise because of its thermoplasticity Furthermore, sheets and threads had to be cut from relatively small solid blocks, and fabric could be coated only from dilute solutions Goodyear, Hancock and the pioneers associated with them developed methods for masticating rubber to make it more plastic, cohesive and soluble,

CHARLES GOODYEAR'S DISCOVERY OF VULCANIZATION
AN ARTIST'S CONCEPTION OF THE EVENT AS IT OCCURRED IN THE KITCHEN OF HIS HOME, WOBURN, MASSACHUSETTS, IN 1839


THE FIRST RUBBER MILL HANCOCK'S MASTICATOR

calenders for making large sheets and for coating fabrics and the method of vulcanizing rubber with sulfur which, for practical purposes, eliminated the thermoplasticity of rubber, made possible the formation of molded rubber goods and made available ebonite, as well as soft vulcanized rubber The paper on "The Work of Thomas Hancock" was presented by Mr A A Glidden and that on "The Work of Charles Goodyear" was written by Mr R W Lunn, whose attendance was prevented by the war, and was read by Mr W B Wiegand In addition, the inventors were allowed to tell their own fascinating stories through the presentation at the banquet of a single volume containing facsimile

TIRES -OLD AND NEW

STATUE OF CHARLES GOODYEAR, TRIBUTE TO INVENTOR OF VULCANIZATION BY GOODYEAR TIRE AND RUBBER COMPANY, ON THE 100TH ANNIVERSARY OF THE DISCOVERY. THIS STATUE STANDS IN FRONT OF AKRON CITY HALL.

copies of "Gum Elastic" by Goodyear and "Personal Narrative" by Hancock

The papers of W A Gibbons, J M Bierer and P W Litchfield describe the technical and industrial growth of the industry to its vital position in modern civilization

In discussing "Lessons from the Past," President Conant emphasized the frequently forgotten fact that scientific progress is greatly helped by industrial progress and that the trend of science is influenced to a large degree by the social and economic environment President Compton told of the effect of synthetic chemistry in removing "the need for employing armies and navies to acquire the world's natural resources" and predicted an accelerated rate of scientific discovery

At the symposium on "The Vulcanization of Rubber" the technical descendants of Charles Goodyear discussed the progress of their attack on the problem which was revealed by his discovery of the phenomenon Here, as elsewhere, the lonely pioneer has been replaced by an army with modern weapons of chemistry, physics and botany

PORTRAIT OF GOODYEAR
AND AN EBONITE TABLE MADE BY HIM

The technical importance of vulcanization is due to the physical changes induced by it—reduction of plasticity, increase in tensile strength, fatigue life, resistance to oxidation and the stabilization of these properties to both higher and lower temperatures These changes are all affected by the use of such compounding materials as accelerators, activators, fatty acids, reinforcing pigments and age resisters, as well as by the temperature of vulcanization and the variability of plantation rubber A number of vulcanizing agents other than sulfur have been discovered, and Dr Fisher reported that he has obtained good vulcanizates by the use of age resisters with oxidizing agents In comparatively recent years the use of rubber latex has grown to large proportions and a big industry has grown up based on "devulcanizing" or reclaiming of vulcanized scrap All these various problems were discussed from the view-point of chemical reactions, physical structures, thermodynamics, x-ray studies, electrical properties and technical utility

Since an understanding of vulcanization requires an understanding of the structure of rubber and the mechanism of elasticity, it was natural that these subjects should also be discussed

Synthetic rubber, long of scientific interest, has become of practical interest because of the development of oil resistant rubbers in the past decade The outbreak of war in Europe and its possible effect on the supply of so strategic a material as rubber greatly stimulated this interest Consequently, in addition to formal papers on synthetic rubber-like materials and the preparation of butadiene from petroleum, there was considerable corridor discussion of the manufacture and use of various types of synthetic rubber

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OPENING OF THE BUHL PLANETARIUM AND INSTITUTE OF POPULAR SCIENCE IN PITTSBURGH

WITH the opening of its "Hall of Light" in early January the new Buhl Planetarium and Institute of Popular Science, in Pittsburgh, was in complete operation At the same time, the workrooms for amateur astronomers, where they can construct their own telescope mirrors and mountings, were made available for members of the Amateur Astronomers Association of Pittsburgh

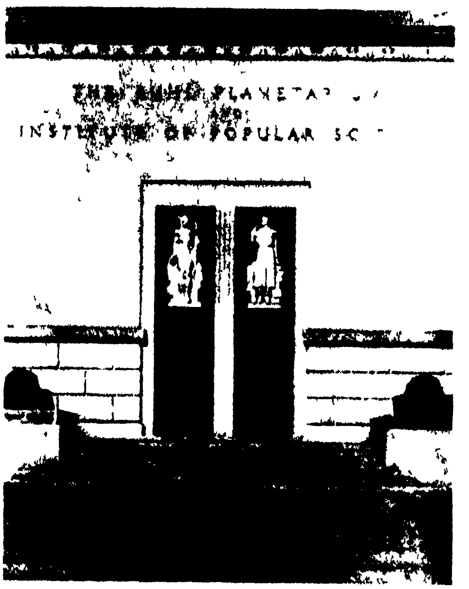
The other sections of the institute opened with ceremonies held in late October These included the "Theater of the Stars," equipped with the fifth Zeiss planetarium in the United States, the "Hall of Astronomy," a number of exhibits relating to chemistry and physics in the main entrance hall, a large gallery for temporary exhibits and a lecture hall

The entire institution is a memorial to the late Henry Buhl Jr , Pittsburgh merchant, who died in 1927 and, by his will, established the Buhl Foundation Chatham Village, a housing project that has attracted attention internationally, research programs, historical publications and many other educational activities have been sponsored by the foundation, which made a grant totaling about $1 100,000 for the erection and equipment of the new institute

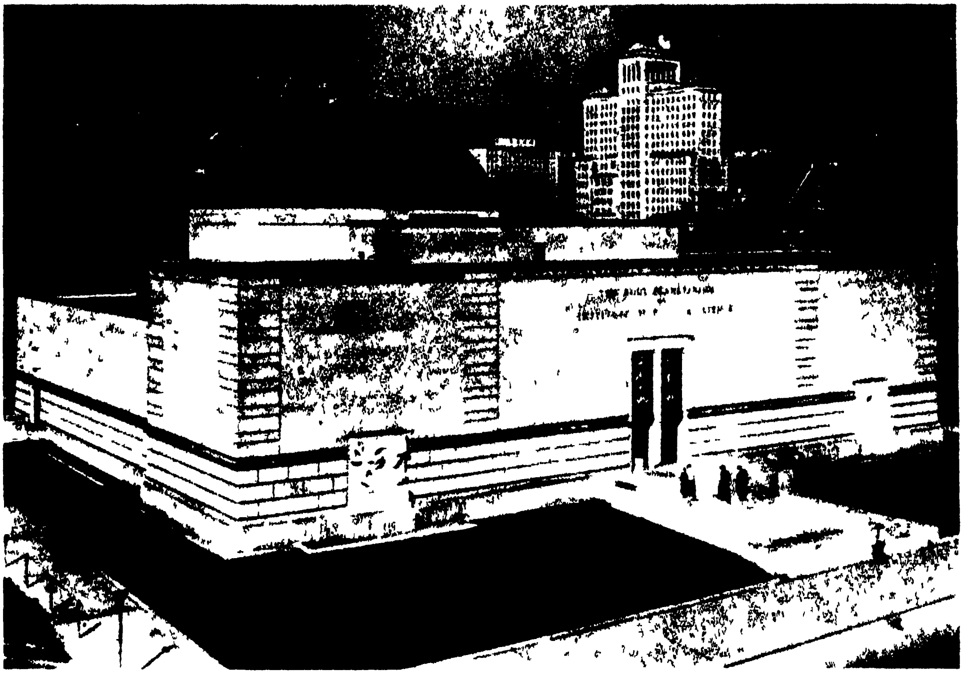
The limestone building was designed by Ingham and Boyd, Pittsburgh architects, and is decorated with six sculptures by Sidney Waugh, of New York It is located on the city's North Side which was the city of Allegheny before the consolidation with the city of Pittsburgh, which took place in 1907 In fact, the site is the one formerly occupied by the Allegheny City Hall In addition to being central, the location is particularly appropriate in several ways Mr Buhl's business life was centered in this section of the city Not far away is the Allegheny Observatory, with its long record of valuable researches under the directorship of such famous astronomers as Langley, Keeler, Schlesinger, Curtis and Jordan This was also the region where lived and worked the well-beloved "Uncle John" Brashear, telescope maker and popularizer of science

Opposite the building is Ober Park, which has been redesigned in keeping with its new environment On one side is the Carnegie Library, on the other the Post Office, while a short distance away stands the new Allegheny General Hospital Ten street-car lines pass the building, and seven others come within a block, so that it is easily accessible from all parts of the city

Entering the building through revolving doors from West Ohio Street, the visitor is in the middle of a large hall, 32 feet deep and 148 feet wide, and with a ceiling 27 feet high, with terrazzo flooring and a wainscoting of Sienna marble This gallery, like all the exhibit halls,



DOORWAY OF THE BUHL PLANETARIUM



THE NEW BUHL PLANETARIUM AND INSTITUTE OF POPULAR SCIENCE

has no windows, which makes for complete flexibility in arrangement of exhibits. Towards one end hangs the Foucault Pendulum to demonstrate the Earth's rotation, while to the other end of the hall is a large rotating drum showing a Periodic Table of the Chemical Elements, with samples of almost all of them and surmounted by a revolving globe of the Earth. Around the Foucault Pendulum are grouped a number of exhibits relating to physics, especially electricity, and around the Periodic Table are chemical displays. One of these shows the growth of plants under artificial light, and with nutrient solutions in place of soil.

From the west end of the main hall, one enters the Lecture Hall, seating 250 persons and equipped with complete projection equipment for silent and sound motion pictures, in 16 and 35 millimeters, and for lantern slides. At the front is a lecture table with all needed facilities. Like other parts of the building, the lecture hall is air-conditioned.

In a corresponding position, at the east end of the building, is the Hall of Astronomy. The wall at the far end shows an arc of the Sun and the planets to the same scale. Below are diagrams showing the orbits of the planets and five scales with dials to show what one's weight would be on Eros, the Moon, Jupiter and the Sun, as well as on the Earth. Along the walls are exhibits showing methods of time determination and time-keeping, and observatories of the past and present. Other displays illustrate motions of the stars. In the center of the room are shown a group of medals and cups presented to John A. Brashear and a collection of meteorites. One of these, weighing nearly 700 pounds, is arranged to tell its own story. When the visitor presses a button, a record is started in another room and a

ENTRANCE GALLERY OF BUHL PLANETARIUM IN SIENNA MARBLE

spoken explanation is heard By an intricate wiring system, exhibits in all parts of the building may be made to tell their own stories in the same way

Through the middle of the Main Hall is the entrance to the "Theater of the Stars," the planetarium chamber, 65 feet in diameter, and provided with a perforated metal dome, which has proven to be the best for the purpose The planetarium projector, for the first time, is mounted on an elevator, so that it may be removed completely from the chamber and the floor covered This makes possible greater realism, for the room can be darkened without the audience being conscious of the machine It also permits greater latitude in giving special performances, for which there is a stage This, too, is removable A section of the wall opens, and the stage can be rolled out, by electric motors, into the room Complete air-conditioning keeps the chamber comfortable Full projection equipment for slides and motion pictures, apparatus for recorded music and an electric organ are also provided and used regularly The room has seats for 492 spectators

Two wide stairways from the Main Hall conduct the visitor to the lower floor First he reaches a mezzanine, and from this he can go into an octagonal room below the planetarium chamber This is devoted to temporary exhibits For the first few months it was a "Hall of Safety," with tests for safe driving, provided by the Aetna Casualty and Surety Company Later it will be used for an exhibition of photography and for a School Science Fair, with scientific exhibits made and shown by high-school students

At the front of the lower floor, under the Main Hall, is the "Hall of Light," with exhibits showing the spectrum, the stroboscope, fluorescence, formation of images by mirrors and lenses, etc As

in other halls, most of these exhibits are action ones, operated by the visitor Several are equipped for spoken descriptions Adjoining the hall of light at one end are the workshops of the Amateur Astronomers Association At the opposite end is a "Club Room" for meetings of a hundred or less The rest of the ground floor is devoted to the mechanical facilities of the building, air-conditioning, machine and woodshops, photographic laboratories, etc

The offices are on the second floor, and on the third floor is space for an observatory, which will be opened in the late spring This will be provided with a 10-inch siderostat telescope, made by the Gaertner Scientific Corporation of Chicago Having a fixed eyepiece, used from a closed observing room, while the telescope lens and the flat mirror feeding it are in the open, this is an ideal type of instrument for a public observatory Because of the importance of the Pittsburgh area in science and technology, it is felt that the Buhl Institute will fill an important place in the community By continual change of exhibits and demonstrations, it is believed that the steady interest of the people will be aroused Scientific demonstrations and showings of scientific motion pictures will be given in the lecture hall In the Theater of the Stars, full use of the stage and other facilities will be made to dramatize the subjects presented, and thus to interest a section of the community which might otherwise remain aloof Outstanding displays of industrial science will be shown in the Octagonal Gallery The Hall of Light will not be permanent, but will later give way to correspondingly complete display of some other branch of science, such as radiation, in general, or perhaps some subject relating to chemistry or biology

Admission is charged to the planetarium, but the exhibits in the various halls are free The admission will be the main source of income The institution is under the control of a board of managers, consisting of the four members of the Buhl Foundation board—William S Linderman, Arthur E Braun, Andrew W Robertson and Colonel Charles A Brooks—Dr Charles F Lewis, director of the foundation, who is the president, and, *ex-officio*, the mayor of Pittsburgh and a representative of the city council The Honorable George E Evans fills the latter post

James Stokley,
Director

MORE SPEED IN CAMERA LENSES

An enormous amount of progress has been made in the speed with which photographs can be taken since Daguerre startled the world with his first pictures a hundred years ago His wet plates were followed by the much more convenient dry plates, which have become increasingly sensitive and rapid. Indeed, since the great 200-inch telescope was started the increase in sensitivity of photographic plates, especially for red light, has made the old 100-inch Mt Wilson telescope nearly as effective for celestial photography as it was expected the larger new telescope would be In other words, the speed of photographic plates, especially for red light, has more than doubled in about five years

The speed of a camera or other photographic instrument depends also upon its objective, or the lens which gathers the light Obviously the brightness of the image on the photographic plate is proportional to the area of the objective, that is, to the square of its radius For this reason the objectives of the portrait cameras before the advent of modern sensitive plates were generally several inches in diameter The 200-inch telescope is being constructed at a cost of

about $6,000,000 because of its great light-gathering power

The image formed by an objective is obviously brighter the smaller it is—the same amount of light on a smaller area The image is smaller the shorter the focal length, in area inversely as the square of the focal length For this reason cameras of continually decreasing ratio of diameter of objective to focal length have been produced Other things being equal, a camera whose focal distance is twice the diameter of its objective is four times as fast as one in which the ratio is four to one

Objectives of short focal length meet a serious difficulty—the curves of their lenses must be steep The steeper they are the greater their aberrations and the greater the number of lenses that must be employed to correct the defects The lenses of nearly all cameras consist of at least three lenses, those of very short focal ratio, of at least five lenses At each surface of these lenses there are reflections, the more serious the steeper their curves These losses are so great that a camera objective of five lenses transmits to the photographic plate under the most favorable conditions only about 60 per cent of the light that falls upon it The remainder is not only lost to the image but is scattered, and part of it produces spurious effects upon the plate

Recently Dr C Hawley Cartwright, of the Massachusetts Institute of Technology, has greatly reduced the reflections from the surfaces of compound objectives Indeed, for the focal length ratio of two to one in five-element objectives he has doubled the speed The underlying principle used is that losses by reflection are reduced when lenses are covered with very thin layers of transparent media of low refractive index The thickness of the layers is of the order of half of the wave-length of the light it is desired to transmit as completely as possible

Such substances were found by Dr Cartwright in the metallic fluorides Unfortunately, the films of these materials can be deposited on the surfaces of lenses only in a vacuum, a fact that adds considerably to their cost Yet in quantity production the costs will doubtless be reduced until the lenses of all high-grade cameras will be coated with thin films—indeed, microscopically thin films—having the properties of transparency and low refractive indices In this new way another important step will be taken in increasing the speed of cameras

F R MOULTON

HOUSE-HEATING BY SOLAR ENERGY

FOR many years scientists have been interested in the problem of using radiant energy received from the sun as a source for heating and mechanical work Dr Charles G Abbot, director of the Smithsonian Institution, has constructed a series of notable solar engines that have attracted much attention Now the Massachusetts Institute of Technology has taken up the problem of house-heating by solar energy with the aid of a gift of nearly $650,000 from Dr Godfrey L Cabot

Enough solar energy is received each year on nearly any building, even a manufactory, not only to heat it but to operate all the machinery it would contain Expressed in terms of horsepower, the energy received by the earth from the sun amounts, on the average, to about three eighths of a horse power per square yard Of course, the amount received depends upon the latitude, but it does not vary as much as is generally supposed For example, at the earth's equator the amount of solar energy per

unit area received per year is only about 2 5 times as much as is received at the poles, though the distribution differs widely throughout the year

The amount of solar energy received by any place on the earth varies each day from zero (except in polar regions) to a maximum depending on the latitude and the time of the year. In order to have available an unfailing and uniform supply, some effective and feasible storage system is necessary Lest it be feared that the energy received from the sun would not be sufficient, even if it could all be used, to heat a residence, it may be remarked that on a house 30 by 36 feet (10 by 12 yards) in floor dimensions solar energy is received, on the average, at the rate of 45 horsepower This energy for 24 hours is approximately equivalent to the total energy in 160 pounds of good coal Since no house 30 by 36 feet in dimensions uses, on the average, more than 160 pounds of coal a day, solar energy is sufficient for house-heating in mid-latitudes providing it can be efficiently stored and used

How can energy be stored? Theoretically there are many ways—as heat, as chemical energy, as electric energy, as potential mechanical energy For various reasons the storing of energy in the form of heat is the most promising All that is necessary is to provide something that will absorb solar energy as heat when the sun shines, store it safely and economically, and deliver it whenever it may be required For very good reasons the scientists at the Massachusetts Institute of Technology have chosen water as the material in which to store energy In the first place, water is cheap, easily handled and safe. In the second place, more heat is required to raise the temperature of a pound of water a given amount than to raise the temperature of a pound of any other solid or liquid the same amount And conversely, in giving up a certain amount of heat the temperature of a pound of water is lowered less than the temperature of a pound of any other solid or liquid is lowered in giving up the same amount of heat. For example, the temperature of iron would be lowered five times as much as the temperature of water Consequently, water is the ideal material for storing heat without using high temperatures

Obviously, the problem of getting solar energy into water and preventing its escape until it is required is a serious one It can undoubtedly be solved provided we will pay the cost There is no prospect that at present solar energy can be used for such purposes as house-heating in competition with coal and petroleum But eventually coal and petroleum will be exhausted, last in North America because this continent contains a considerable fraction of the known petroleum resources of the world and over half of all the coal Long before that time comes scientists will have found other sources of energy, the most promising of which is the sun, from which essentially all terrestrial energy has directly or indirectly been received For example, it is solar energy that raises water to high levels in the air, that drives the winds that turn our windmills and fill the sails of our ships, that is stored up by photosynthesis in the myriad chlorophyll cells of plants, some of it later to be available as food or coal or petroleum

F R M

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APRIL, 1940

SCIENCE AND SOCIAL EFFECTS: THREE FAILURES

By Dr ISAIAH BOWMAN

PRESIDENT OF THE JOHNS HOPKINS UNIVERSITY

THE future of human enterprise is predictable in part only, and most often in terms of *if* To increase our technological efficiency by 20 per cent, would permit us to pay off our national debt in a generation, *if* the corresponding net profits were not dissipated by multifarious waste or social inefficiency Every proposal, fact, or condition has wrapped up in it the mystery of its contingent event, a mystery designated by *if* One thing leads, commonly, to another that is not foreseen or expected

This warning is essential at the beginning of an argument on the solid achievements of science (in fields of limited fact and experience) which tempt us to expect too much of social applications "Science tells us" is a phrase of confidence to which we have all become habituated This has its dangerous as well as its hopeful aspects We have yet to prove that, in Wheeler's phrase, we are not just so many "juicy colloids bombinating through the cosmos"

There is a second warning to be observed at the outset Conscious of the limits of forecast in human affairs, we are apt to overlook powers of forecast already won How we came to develop or possess these powers is a fundamental question · the study of their origins will certainly reveal further possibilities, for we cannot suppose that we have done more than begin their development The end is never *now* To enlarge our powers in this field it will be necessary to *know* much more and also to intensify our imaginative and conceptual processes It is equally important, perhaps, to see what hazards beset forecast in the social field. Perceiving a danger pointed out by science, what does society do about it?

It would be easy to compile a list of beneficial effects following upon the application of science to social problems Beginning with public health measures, which are responsible for one of the chief triumphs of associative living, we could pass to comforts and conveniences, lifted burdens, widened horizons of knowledge and deeper intellectual satisfactions Perhaps you expect me to provide such a list of triumphs, for this association is designed to demonstrate the solid human worth of science and give it wider dominion But might it not prove equally useful, now and then, to analyze instances of social failures which were definitely forecast if the related science were neglected? I propose to describe three failures in at least one of which forecast has been fully verified They relate to the hitherto unsolved problems of peacemaking, the decline of the oyster industry of Maryland and the destruction, with tragic human consequences, of certain tropical soils

A distinguished member of one of the European delegations to the Peace Conference of Paris (1919) bade me goodbye with the remark, "I return home a deeply disappointed man I came believing that through my science I could successfully support my country's claims and help win for it a dominating place in Europe" What he meant was that through his science he had acquired a systematized body of knowledge and an explicit and impressive terminology by the aid of which his national leaders might win advantages at the expense and to the disadvantage of neighbors Science in my friend's case became advocacy for nationalistic aims. in short, it ceased to be science.

Clemenceau rejected science altogether He had a severely practical view with respect to the political aims of 1919 Said he, "The appeal to abstract justice demands judges France, England, America had bought with their blood the right to that high office They could dictate forms of justice That is how civilizations progress" There were two fatal defects in his philosophy. Whose justice? What force should maintain it? Treaties must be made as best they can, almost *at moments,* whereas an ordered or scientific and humane society is a thing that must evolve over the years and with continuing trial, error, and revision

We deceive ourselves if we think that just at the close of a victorious war we can improvise a Utopian peace It was not done in 1919 Who has learned to do it in 1940? *There is no science of justice* In fact, there are diametrically opposite opinions on and feelings about justice because the litigants are the judges Science can tell us where a boundary should run to provide equality of *strategic* advantage to bordering states, it tells us where it should be drawn to distinguish *ethnic* differences, it discloses how states should be delimited to provide industrial *power* in proportion to population It can not provide the political and moral bases for the optimum combination of these conflicting and disparate interests and conditions

We shall make better progress in the next peace if we look for the faults of the world not in treaties but in the underlying and as-yet-unsolved problems with which men grapple who make the treaties No treaty can leave everyone satisfied. This is not due to conflicting greeds only. It springs from cultural differences and commitments, from unequal resource inheritances, unequal aptitudes and powers, fear, ambition, propaganda A Versailles does not solve problems arising from such diverse sources it only rearranges the problems. Will the next peace treaty do more? Wisdom *evolves through time* like the rest of man's social and moral equipment A war treaty is framed in an emotional atmosphere, and a coalition of victorious powers has a terribly hard time agreeing on terms among themselves, not to speak of agreement with the enemy There is, in short, no well-understood and accepted substitute today for what Clemenceau called, in 1919, "dictated forms of justice" It is clearly unscientific to be forced to define and document world justice while fifteen million men are under arms.

Statesmen and politicians deal with feeling, prejudice, pride, in short, folk psychology about folk-lore If they resort to scientific terms it is only to give feeling an appearance of solid underpinning Newtonian principles and terms have often provided statesmen with a nomenclature "that seemed to exhale the odor of ultimate truth." Political gravitation, natural rights, invincible law, a scientific border, rule of propinquity, geographical claim, organic growth—all are terms of rationalization that have been employed by political leaders, adventurers, arguflers, military

chiefs, scholars. For example, all of them have been used, as Weinberg has shown in "Manifest Destiny," to give America a national thesis whose ultimate defense required nothing additional except an appeal to patriotism tinged with morality!

Beginning with Jefferson in 1806 and coming down to 1940, the changes have been rung upon the "scientific" proof of theses that have to do with economic doctrine, political programs and social objectives At this moment the limits of disputed territorial claims to unoccupied spaces in the Arctic and the Antarctic follow meridians as if a logical quality were imparted to a claim by bounding it with imaginary lines that are familiar features upon the library globe and in "mathematical" geography If *fairness* were the only recognizable basis of territorial claims and national "rights," then scientific methods might have nothing to do with boundaries But *there is no science of fairness* In general, that is fair between two peoples which is voluntarily and freely agreed to be fair under approximately equal conditions of knowledge Science and fairness are often in happy and useful relation in the affairs of states the important thing is that we have not made the relation inevitable or general.

Science should be indispensable in international affairs if only because it reduces the number and extent of areas in which feeling alone dominates, or national prestige, or political rivalry. Science deals not alone with assured fact but also with probabilities For instance, it does not reveal at a moment of time exact knowledge about the total quantity of petroleum in the earth's crust and its geographical distribution, rather, it reveals a known or inferred quantity, the probabilities with respect to further discoveries of new fields, and the extent, efficiency and cost of existing recovery methods. Modern chemistry hints that the *amounts* in given categories of natural resources within national boundaries will take on new meanings in the light of further scientific progress. But no one can predict such changes in meaning, or announce the growth rates or *aptitudes* of the future population, or their relation to existing resources and future welfare with sufficient accuracy to provide a sure basis of national policy. Nor can we measure public spirit, the depth of appeal of tradition, the capacity to develop a united world program that demands nationalist sacrifice

But what of the areas in which science may play a part? A single item in a series may be mentioned As surely as night follows day, the problem of postwar production in the face of delayed industrial reemployment of discharged soldiers will tax the ingenuity and financial power of Western civilization We can not talk of "gradual adjustment". A man may starve in less than a fortnight Taxation and relief (or its substitute, war industries) have limits to which Europe is dangerously close. To stop war industries and *not* start a substitute is to invite disorder if not disaster. If peace were possible to-morrow, could the world afford to stop its war program without having a peace program ready for adoption?

Confronted with these difficulties ought not the power states to be about the business of creating new industries, surveying and appraising underdeveloped land that might provide not mere additions to world surpluses but support for largely self-contained economic units producing wanted exports, closing the gap between full productive power and our present deficient consumption? In these processes science is indispensable. It is ready to go A sum equal to the cost of one battleship would give it enormously increased motive power Reparations and armistice terms will not supply that motive power, nor will loans,

tariff adjustments, shipping pools and currency stabilization schemes supply it, helpful as some of these *arrangements* may be What is wanted is something deep down, not an arrangement but an addition

II

Before most readers of this article had entered the primary school, Professor W K Brooks of Johns Hopkins first fertilized oyster eggs artificially and began the study of the development of the oyster embryo He was fond of saying that he had hatched from artificially fertilized eggs more oysters than there were inhabitants of the United States From 1883–84 he served as oyster commissioner of the state of Maryland He forecast with astonishing accuracy what President Gilman called the decline and fall of the oyster empire of the Chesapeake

He was a trumpeting Gabriel when it came to social effects which he wished to correct He heralded grave losses to everyone in Maryland (not merely to the dredgers, dealers, packers and carriers of oysters) if the destruction continued, and he declared the advantages to everyone in the state if human intelligence, industry and science were to supplement the bounty of nature Instead of using intelligence, said he, we "snatch a slight tribute" from our natural store of bounty and pay no attention to the state of the water and the black bottom mud of the bay that have a vital relation to the biology of the oyster, thus using not a "hundredth part of our advantage"

Basing his argument upon an intimate knowledge of the oyster and upon the then existing state of the industry, he called attention to the lack of thorough surveys and maps of the oyster beds, surveys that might give an accurate picture of their progressive exhaustion and, indeed, indicate their ultimate ruination His studies revealed a 50 per cent decline of oyster population in a period of three years (1879–1882) The announced results were dismaying He pointed to the accidents and enemies of the oyster, especially during its first year of life A change of climate was appealed to by some in explaining the decline of the supply, others thought that the taking of oysters for private use in the summer was the chief cause, still others threw the blame upon the officers of the Fishery Force Measures of conservation were nobody's business

Brooks called for an annual examination of the industry and the recognition of the essential failure of public and private management Instead of relying upon the lazy, vague and ignorant principle of the "play of natural forces," he pleaded for the artificial increase of the oyster population, just as the domestication of sheep, cattle and poultry had displaced the hunting of wild deer, wild buffalo and wild turkey He wrote in 1890, "We live in a highly civilized age and if we fail to grasp its spirit we shall go to the wall in the oyster industry"

It was thought doubtful if the industry could get better until it had become decidedly worse Short of widespread social effects, how could the people of the state appreciate the situation and apply scientific remedies? Brooks called attention to the absolute silence in which a prior statement of his rational remedies had been received He recommended laws requiring the return of shells to the beds, he calculated the loss to the state if the practice of gathering and selling immature oysters were continued, above all, he encouraged oyster planting in Chesapeake waters The prohibition of dredging would not save the beds Laws shortening the season would not effect any great improvement, he thought

I shall make no attempt to present the complete case as set forth in his book first published in 1890 and republished in 1905 The point is that he made a scientific study of a biological form, ana-

lyzed an industry built upon it and forecast specific social effects His work has stood every test of criticism for fifty years He brought experimental science and new discoveries of the laboratory to bear directly upon a large industry in a small state He predicted with accuracy the course of events during the next fifty years if the findings of science were ignored The fatal evolution of the industry in the past half century is one of the most remarkable validations of scientific method which we know He dealt out foundation material which was rejected by the political builders

During the ensuing half century successive legislatures sought to protect and encourage the industry, but they did so by consulting so-called "practical" oystermen Lay opinion was substituted for scientific opinion, the profits of the moment for continuing profits Compromise of conflicting interests in the bay region were sought to provide a form of democratic control with little regard for the substance of the problem

I have ventured to present this somewhat detailed account of a single industry in order to point a moral Scientific methods and political methods are too often incommensurable or are made so The democratic process requires debate, general knowledge and education, and, in the final analysis, compromise If these form the essence of the process, they impose severe limitations In scientific matters we may reach a point where we may say with confidence, as Brooks said, "Science tells me that the effects of the present policy will be disaster" The politician meets this statement with the observation, "Come now, you don't know everything Let's look at the *practical* issues involved in this matter Are you unwilling to compromise? Is not compromise the very essense of the democratic process?"

Most human situations can be compromised on a basis of fairness because a sense of fairness rests not upon statistics (of wages and cost of living, for example), but upon a *feeling* with respect to these things But we do not study atoms or oysters by feeling! Nor does feeling count when it comes to the study of chlorophyll or pigmentation or the social conditions favorable to the spread or control of disease What science gives in these instances is precise or closely accurate results over vital sectors of the problem Thereafter, measures of control are validated on the basis of determined cause and effect, not on the basis of compromise as to the relation of cause and effect Over some parts of the domain of science, we have precision, sureness, forecast, these findings sometimes point to a right way and a wrong way but not to a middle way of compromise

While I believe in the democratic process and in the ultimate attainability of the ideal, I can see no present answer to the above dilemma except that of education True, we shall have selfishness and deviation to deal with even if all are educated to the truth But in just the proportion that we increase the area of reasonably sure knowledge and conclusion and high probability of correct forecast, we diminish the area which selfishness can safely or secretly occupy We do even more than this, we *show up* selfishness or deviation The findings of science thus reveal more than science But science does not give us the total social answer It does not close the gap between findings and actions An instinct for the practical and the fair has its place Interest will still be a major propelling force when we have had all the science that the human race can evolve Social action is based upon assumptions (expressed or implied) respecting human values Feeling and "judgment" will continue to play their vital part in the totality of human affairs Ideas, beliefs, habits and the customary mental concepts that hang in the picture

galleries of our minds will still color when they no longer guide our behavior. The essential thing is that we shall recognize these forces for what they are and appraise them for what they are worth

III

The hopes of society make half the problems of society These hopes are mainly untested ideas and half-formed judgments that grow in pools of limited experience and knowledge A science of society, or science applied to society must take account of human hopes, how they form, the facts of their existence and impact in the evolution of social programs.

Science has opened the door for hope on innumerable occasions We may mention two great categories of achievement among many · a knowledge and command of the material or resource environment in which we live, and a rising knowledge and command of world resources outside our respective neighborhoods It now faces the exigent task of appraising and *apportioning* the world environment, not alone the national environments of power-creating peoples of unequal size and opportunity That appraisal has as its first task the effect of existing exploitation upon both human stock and "natural" resources

New land was once the hope of the world: it was an outlet for overpopulated lands or lands of diminishing opportunity. Economics and sovereignty joined in pointing to the future wealth which new land would supply What was not considered was the longevity of the soil from which the vegetable wealth was to be drawn One hundred years ago the world contained but half its present population It results that until our time new soils had not been tested sufficiently to know what they would *continue* to produce and what demands would be made upon them by the astounding increase of world population and industrial demand. No early end was seen to world migration, world productivity, world capacity: Malthus' predictions lay in the distant future. Students talked of the *exhaustion* of soil fertility, not of the *destruction* of the soil itself A swift fate has overtaken our dreams of tropical inexhaustibility, of lands where "seed time is perpetual" and "harvests never end" as Maury expressed it in 1854 No less than the temperate or optimum lands, the tropics now have their acute problem of soil conservation.

Modern material civilization, pushing into the tropics, has piratically extracted from tropical soils and human labor in many conspicuous instances a short-term tribute for which an accounting is now required in the face of obviously destructive effects Commanding a vast number of power units per individual, employing diversified technologies and offering tempting trading goods, our producers, merchants, and engineers have been able to get what they wanted on a vast scale and on profitable terms Large-scale agricultural enterprise in the tropics is still new but time enough has elapsed to permit a judgment on methods both in relation to the immediate objective and to the future of the tropical lands as a whole

It is no longer enough to say that tropical peoples ought to be grateful because beneficial health measures have been introduced or because material equipment has been increased Whether because of the concomitantly increased pressure of population or because of the white man's insistent demands for ever-cheaper and more abundant tropical production the heritage of the land itself has been wasted "From Cape Town to Cairo, European influence has been responsible for the rapid, and in places now uncontrollable biological deterioration of the land" is the way Jacks and Whyte sum up the soil erosion problem in Africa. From their book "Vanishing Lands" (1939) and its predecessor "Erosion and

Soil Conservation"[1] (1938) and from Lord Hailey's monumental report "An African Survey" (1938) can be drawn a wide range of instances of the failure of the white man in his role as protector of the human and other resources of the tropics

"Money has poured into these (African) countries to release their slender reserves of soil fertility." Again, "The people have been pacified before the elements" A part of the effect is due to peace imposed upon formerly warring tribes by European rule and a corresponding population growth that has demanded that forests should be cleared, the periods and the extent of fallowing reduced greatly, and pastures overgrazed or occupied by hungry farmers seeking additional crop land; to economic arrangements which provide a higher standard of living, and to science which has annihilated insects and vermin in conspicuous instances in which they held the balance between organic and inorganic forces of nature

This is the case in Uganda as summarized by W. S Martin.

Prior to British administration no crops were grown for export and cultivation was limited to the area necessary for food production The banana-eating tribes cultivated gardens of often 3 to 5 acres in extent, but preserved them from erosion by mulching with leaves and split stems They also cultivated small areas of subsidiary food crops, such as sweet potatoes and beans, but these were frequently grown together in the same plot and the soil was thus exposed for short periods only. Their implement was the primitive hand hoe, and the larger trees of the natural vegetation were rarely cut down. Their cultivations were scattered through the bush and the elephant grass, and under such conditions erosion was very limited Similarly the grain-eating tribes cultivated small scattered patches, although these were situated in areas of light, easily erodible soil, they were usually so small that neither wind nor water could effect erosion.

With the advent of European administration tribal wars ceased Medical and veterinary science controlled the diseases to a large extent, with the result that the human and animal population increased Simultaneously trials of cash crops for export were made and 30 years ago it was becoming clear that cotton was the crop best suited to local conditions. At first the cotton plots were quite small and scattered in a manner similar to the food plots, but every plot of cotton represented an addition to the area cultivated At first the native undertook the cultivation reluctantly and under official persuasion, but soon realized the advantages of money and gradually became accustomed to new standards of luxury To achieve and retain these and to pay his taxes he gradually increased his cotton cultivations The cotton acreage in Uganda in 1916, 1926 and 1936 was 133,000 acres, 533,000 acres and 1,500,000 acres [2]

Particularly severe is soil erosion in the densely populated Teso district of eastern Uganda The gently undulating surface and light short-grass bush soils lend themselves readily to the plow, which has largely superseded hoe cultivation Where there were 300 plows in 1921, fifteen years later there were 15,388, and a toll has been paid in eroded and abandoned fields Little wonder that indiscriminate introduction of the plow into Nigeria is viewed with alarm. Native economy is not always a destructive economy frequently the methods evolved by the native farmer are well adapted to conditions as he finds them. Stamp describes the farming methods of Southern Nigeria as affording "almost complete protection against soil erosion and loss of fertility" Within limits the untidy, weedy patches of cultivation scattered among the bush fallow "represent the most efficient type of farming for the conditions" and "it is to be hoped that Southern Nigeria may long be spared the danger of the plow."[3]

In some parts of Kenya devastation is such that "nothing short of the expenditure of enormous and quite impossible sums of money could restore the land

[1] *Bull.* 25, Herbage Publ Series, Imperial Bureau of Pastures and Forage Crops, Aberystwyth.

[2] Jacks and Whyte, "Erosion and Soil Conservation," p. 105, 1938.

[3] *Geog. Rev.*, 28. 32–45, 1938

for human use above a bare and precarious subsistence standard."[4] In the Ukamba Native Reserve more than a third of the total area is badly eroded as a result of bad farming methods and overstocking. In the Machakos section where the rolling hills have been denuded of their forest capping gully erosion is widespread; in the more level Kitui section where cotton cultivation has recently been introduced "sheet erosion has already reached the visible stage on most cotton plots." A. M. Champion, visiting Kitui after an absence of 18 years, found that "some 80 per cent of the foci of cultivation had, during that period, completely changed, leaving behind a deserted wilderness of a particular type of leafless thorn scrub, the only vegetation which the bare red subsoil, itself often case-hardened by an impervious crust and deeply networked into numerous runnels and gullies, could support."[5]

In Tanganyika the problem is less severe as yet, but erosion has to be reckoned with on many types of countryside—from Kilimanjaro in the north, where soil wash of the rich loams has reduced both quality and yield of the coffee plantations to the Lupa goldfields in the south, where former cultivated areas are now barren and uninhabited.

In the older cultivated regions of Southern Rhodesia such as northern Mashonaland overexploitation has destroyed many areas. The average soil loss in the Mazoe district is said to be a quarter of an inch a year. Land that grew good crops of maize a generation ago is now "desert country."

For nearly two decades A. J. W. Hornby has been preaching the evils of soil erosion in Nyasaland. "The damage caused by unsettlement, destruction of forest by fires and unregulated felling and inferior methods of agriculture has been both rapid and intense. . . . it will not be many years before the limit of possible food production will be reached." He finds an important cause in "the past and present methods of most natives, the recent immigrants being most to blame."

South Africans of highest distinction have called the attention of government and people to the devastating effect of the white man's occupation of the subcontinent. The South African Association for the Advancement of Science has kept the subject in the forefront of its successive programs for many years. A Drought Investigation Commission reported in 1923. The forty-seven specialists pointed to the deterioration of soil and vegetable cover as the "main causes of the decreasing European population of the Cape Midlands." The farmer knows that drought will come sooner or later, yet he makes no provision for it, with the result that he overgrazes in times of short pasture.

In the report of the Drought Investigation Commission there is a comment which goes to the heart of the subject of this paper. The specialists state that they can not recommend any direct legislative action to control overstocking or veld fires because such action could not be enforced. They add: "Unfortunately, in a democratic country it is not possible for Governments to introduce measures too far in advance of the wishes of the average voter." The mournful conclusion is reached by Thomas D. Hall, writing in 1934, that if something is not done quickly to speed up erosion control and veld management, South Africa will one day be merely another interesting historical example of how democracy, carried to excess, destroyed itself. "We can not wait for our unteachables to act by way of the ballot box—for it will then be too late."

All South African farmers, says Du Toit, speaking at a symposium on con-

[4] Jacks and Whyte, "Erosion and Soil Conservation," p. 95.

[5] *Jour. Royal African Soc.*, 38: 442–464, 1939, reference on pp. 448–449.

servation, have had practical proof of the generally low quality of their soils Very few, however, have realized that to cultivate them by methods practiced in more favored lands is to put too great a strain upon "this tender cuticle of the earth "[6]

These examples have been drawn from Africa, but we could draw equally well from other tropical and semitropical lands—the teak and rubber plantations of Ceylon, the deforested foothills of northern India from Assam to the Siwaliks, in many islands of the West Indies, even in Java, where tropical agriculture records such admirable successes, there are "dying" lands

Both native cultivations and European plantations suffer "Nearly all countries which have been opened up for any kind of 'planting' afford striking object lessons in what ought *not* to be done "[7] The exploiting white man has been unable to make his economic scheme take account of the science that has given him power over the native and his land

It is asserted that in one tenth of the time that it takes to develop serious erosion upon soils of the temperate regions, tropical soils begin to show erosion effects where erosion potential is evident But not all tropical soils suffer from erosion Deviate but slightly from appropriate methods of land utilization, as by shortening the rest period of shifting cultivation and the soil-plant organism responds sensitively with destructive effects Each crop and each method of cultivation must be studied in relation to each soil type, each vegetation type, each rainfall type, each slope gradient, in combinations that have to be analyzed fundamentally to provide an acceptable long-term scheme of cultivation

Rainfall in the tropics is predominantly a matter of heavy downpours in short intervals of time, and in many parts of the tropics the total annual rainfall comes almost exclusively in the wet season The type of cultivation suited to a given soil is therefore a matter not only of soil structure alone but also of rainfall conditions in detail Each regional environment is a different thing to different groups of people accustomed to distinctive food crops and modes of tillage

Vageler concludes that it is hardly too much to say that more than 75 per cent of all failures in tropical and subtropical countries are due to the choice of unsuitable land

The Second Conference of East African Agricultural and Soil Chemists held at Zanzibar in 1934 discussed the principle of "making surveys before framing policies " "There was need," it was argued, "for a field study of eroded and potentially erodible areas, in which not only the present intensity of damage should be reported upon but also the soil profile and all the factors associated in its development "

A world-wide comparative survey is indicated We do not know enough about the weathering processes that affect the soil-making and soil-maturing processes of nature Organic acids, soil micro-organisms, vegetal cover and population balance are elements in the problem A rapid ecological survey can not take the place of a thorough soil and climatic survey Vageler quotes native opinion that in the Dutch East Indies three years are enough to destroy the richest humus, if the trees are felled and the soil exposed The principles of good soil management in the tropics have yet to be determined Temperate zone analogies are misleading The principles must be more widely recognized and surveys must be made before policies can be framed

We have assured profits for the time being to commercial enterprises in the far-flung acreages that now lie devas-

[6] *South African Jour of Science*, 35 20, 1938

[7] *Empire Cotton Growing Review*, 6 297, 1929

tated and barren We have equally assured the destruction of the soil All our other scientific achievements in tropical exploitation will fall if the base is destroyed, and that base is not profits but the land upon which tropical peoples dwell These peoples know nothing of our objectives. Nearly 100 per cent. of them must make their living by growing crops or raising cattle. Unless we build up a permanently productive soil, tropical production in the devastated lands will collapse and all our engineering skill and our control of tropical diseases will be but memorials of misused power.

The point is of crucial importance at the present time because the control of tropical diseases, both human and animal, and the introduction of air-conditioning in living quarters are likely to result in an even greater demand for and utilization of the most suitable and still uneroded tropical soils In the absence of any clear philosophy of control by society of the forces which science has delivered into the hands of this generation, and in the face of the limitations imposed by political management, tropical exploitation bids fair to become a major problem in world recovery following the present war when both production and distribution will make fresh demands upon our wit and our science.

I fear that I have been writing for the converted merely, to those who are in no need of either example or moral. The millions of people who may be in need will not hear or read these words. But the scientific man has an obligation thrust upon him It is to debate and to decide in the company of his fellows on a course of action with respect to the progress of science and the weighting of its social effects. Thus will be provided either some degree of confirmation or some disclosure of weakness in our conclusions or our judgment Perhaps it may also make each one of us a more intense and effective advocate of the spirit of science in human dealing: objectivity, an even-tempered attitude, and respect for the limits as well as the contributions and the possibilities of science. The total effect which scientists produce may thus come in time to be large, or to paraphrase Aristotle· Each of us may add a little and from the whole there may arise a certain grandeur.

SEVENTY YEARS OF SUEZ

By Dr. W. O. BLANCHARD
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THE year just passed marks the seventieth anniversary of two epoch-making events in the history of world transport One of these events occurred at Ogden, Utah, at that time an obscure frontier village There, the driving of a spike of gold and another of silver marked the completion of the first transcontinental railroad across the North American Continent. The other event was a colorful pageant staged in the Land of the Pharaohs At Port Said, on November 17, 1869, lay the French royal yacht on whose deck was assembled a remarkable gathering of world celebrities, among them Count Ferdinand de Lesseps At a given signal, the bands struck up, and amidst the cheers of the crowds on shore, the banner-bedecked yacht headed south, leading a parade of half a hundred ships, the first to pass directly from the Mediterranean to the Red Sea through the new Suez Canal

In the three quarters of a century which has passed since that historic celebration, Suez has played a leading rôle in the world of commerce as well as in European politics Its strategic location both for peace-time traffic and for military and naval operations has made its construction, operation and control matters of great international concern As a consequence, the major problems of those in charge have from the very beginning called for the talents of a diplomat as well as those of an engineer

As at Panama, the transportation history of the Suez Isthmus passed through the three successive stages of (1) pack animal, (2) railway carriage and (3) waterway. From remotest antiquity men and camels had plodded across this 100-mile portage of hot drifting sand, bearing the precious bales of merchandise from the Far East Oftener still, the route crossed from the Red Sea to the Nile, thence down that river to the Mediterranean At various times in the past this latter land link was even canalized, but for the decade preceding the completion of the Suez Canal, a railroad from Cairo to the Red Sea at Suez performed this portage service Finally, in 1869, the isthmus was cut and ships passed directly between the Mediterranean and the Red Seas

The trickle of traffic which started through the new waterway in November, 1869, required a few years to get really into its stride Century-old routes with their equipment, sailing schedules and their long-established port and business connections could not be uprooted overnight Prejudice against the new waterway, especially in Britain, died hard, and it was not until two years after the opening that the British Government consented to use it for its India mails. The advantages it offered, however, especially for the Asiatic trade, were so great that the "trickle" soon became a sizable "stream," as shown in Fig. 2. To-day, some 6,000 vessels carrying upwards of thirty million tons of merchandise pass and repass in that narrow defile This short cut between East and West has quickened the economic life of the lands bordering the Indian Ocean as well as those of the western Pacific. Likewise, it transformed the Mediterranean from a "blind alley" to a through route and raised it to a position second only to the North Atlantic among ocean highways

The engineering problems met with at

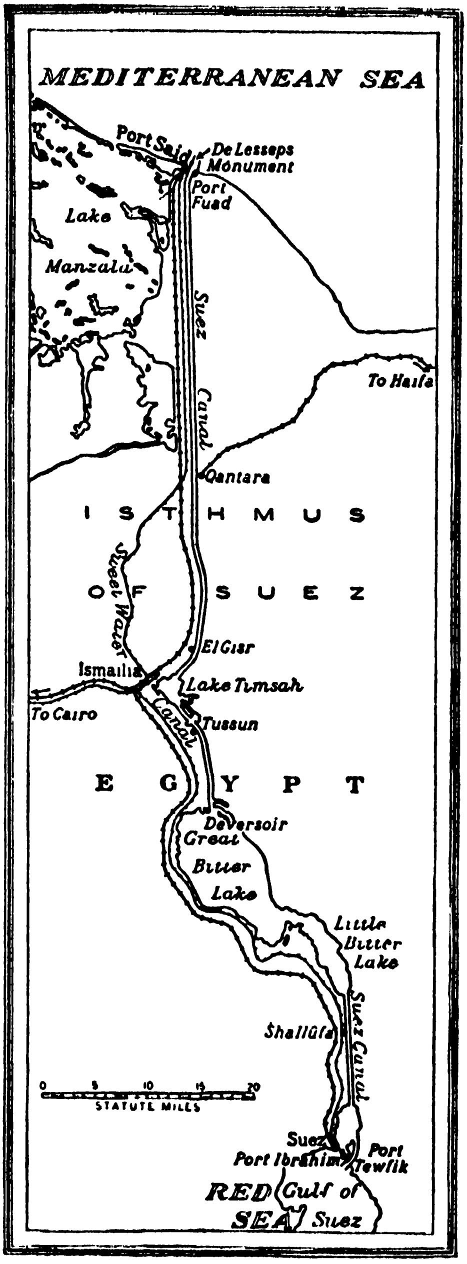

FIG 1 SUEZ CANAL SYSTEM
SUEZ AND SWEETWATER CANALS SHOWING THE RAILWAY AND ENVIRONS

Suez were not at all comparable with those at Panama, a fact that de Lesseps discovered later, much to his sorrow True, both engineering and medicine had made tremendous progress in the half century which elapsed between the completion of the one project and the beginning of the other, yet the natural obstacles, geologic and climatic, encountered at Panama were, by comparison, enormous

Panama required a huge cut to be blasted through a mountain of solid rock At Suez it was largely a matter of dredging out mud and sand, in fact, a considerable part of the excavating was done by an army of some 25,000 laborers, who shoveled the dirt into baskets, loaded them onto donkeys who, in turn, carried and dumped it beyond the edges of the great ditch This led, in the former case, to an expensive and complicated lock-type of canal in which ships had to be raised and then lowered some 85 feet—literally "lifted" over the continental divide For the other, a simple sea-level waterway was quite feasible

Climatically, also, Panama was much more seriously handicapped Situated in the humid tropics, some of its major problems centered about the disposal of excess water and jungle growth and the elimination of diseases that were associated with such a setting At Suez, on the other hand, one of the most difficult tasks was to secure *enough* fresh water for the workmen In the first years of construction, water for the army of laborers had to be brought from the Nile by camels at an enormous cost—some $2,000 a day! By 1863, there was completed a diversion canal which brought fresh water from the Nile Likewise, in the arid climate, the absence of a vegetation cover permitted the drifting of sand that constantly threatened to refill the excavation The answer to this menace was found in a program of continual dredging, as well as in putting a low speed limit on ships using the waterway so as to reduce the wash of the banks.

The early routes that usually led from

the Red Sea across to the Nile necessitated the navigation of the delta of that river—always a difficult feat De Lesseps' decision to construct the new canal across the Suez Isthmus served to avoid the delta problem However, the currents in this part of the Mediterranean carry the Nile mud eastward and a long breakwater has had to be built to prevent the filling in of the mouth of the canal

The Suez route is but one of many competing routes joining Europe with the East These highways extend all the way from the Arctic on the north to the Cape of Good Hope on the south, and they include water, rail caravan, air, auto truck and oil-pipe lines, as well as combinations of two or more of these Even the Panama Canal and the Straits of Magellan are competitors within certain areas The severity of the competition offered Suez varies, of course, with the particular regions concerned, as well as with a large number of variable factors, such as charter rates, canal tolls, insurance rates, fuel prices enroute and the character of the harvests

As illustrative of the influence of location, the case of India and Australia, trading with western Europe, will serve As shown in Fig 3, Suez offers a saving over the Cape route of about 4,500 miles for India, but only about 1,000 miles for Australia For the latter, a tramp vessel going via Suez saves only three or four days of sailing—often not enough to justify the heavy tolls As a result, much Australian and New Zealand shipping still moves around Good Hope

Likewise, if charters are low, savings in distance are less important During the recent depression ship earnings were so small that the time element was of minor importance and many shipping lines shifted routings to avoid the high canal tolls

Occasional changes in the canal tolls and the insurance rates over certain routes are sometimes important factors. Recently when the Italian-Ethiopian conflict and the Spanish civil strife brought war-clouds to the Mediterranean, the increase in war-risk insurance rates there diverted much shipping via the Cape Even oil tankers from the Persian Gulf and some passenger vessels took the longer but cheaper route

The availability of cheap fuel en route is often a strong factor in the choice of routes The development after the World War of the Natal coal deposits in South Africa, providing cheap bunker coal at Durban, and the more recent large output of oil from Iraq and Iran exert an enormous influence upon the popularity of routes passing nearby

Other competition is offered by routes across Arabia or Asia Minor Auto-truck lines join the railhead at Damascus with Bagdad, and 1939 saw the completion of the old Berlin to Bagdad line Air routes from western Europe to the Middle East and Far East cut into the mail, express and passenger movement which

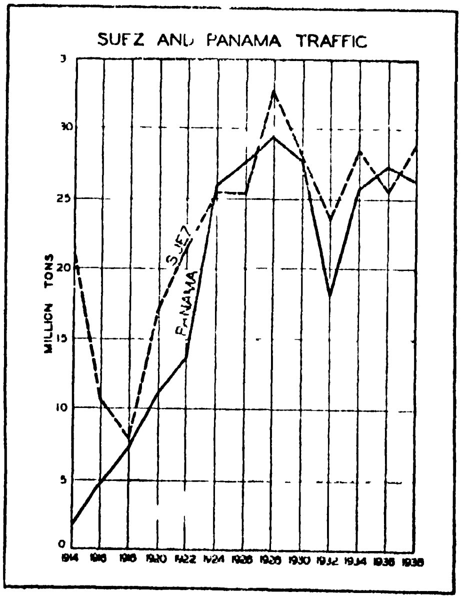

FIG 2 TRENDS IN CARGO TONNAGE AT SUEZ AND PANAMA COMPUTED BY CALENDAR YEARS

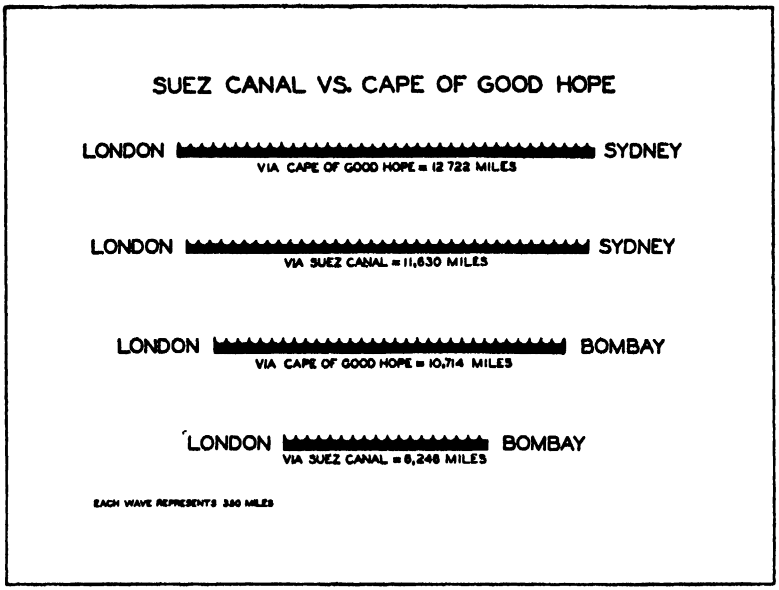

FIG 3 MILEAGE SAVING OFFERED BY SUEZ OVER CAPE ROUTE

otherwise might go via Suez A unique and interesting development is the recently completed oil-pipe lines from Iraq to Haifa and Tripoli Operating at full capacity, this system is able to shunt yearly one third of a million tons of crude petroleum overland direct to tidewater on the Mediterranean

All in all, it is the route via the Cape of Good Hope which is the most formidable competitor of Suez The canal never did succeed in attracting *all* the traffic from that route, and it requires but slight changes in economic conditions to increase the proportion going around Africa

The great bulk of Suez shipping moves between western Europe on the one hand and the borders of the Indian and Pacific Oceans on the other The one is a highly industrial region, and the other, an area in the raw material-foodstuff stage of development As a consequence, the Suez route, like Panama, suffers a lack of balance, the northward-moving cargo tonnage being about twice that southbound Bulky coal from Europe and high-priced tea from Ceylon and India are exceptions to the general rule. Without them the disparity in movement would be even greater.

An analysis of the canal traffic shows that commodities moving south comprise a multitude of manufactured or semi-manufactured articles, while on the return trip there are great staple foodstuffs or raw materials, few in number, but large in quantity As shown in Fig. 4, of the southbound traffic, metals and machinery occupy first place, in fact, it is the only group in Class 1, *i e.*, making up as much as a million tons per year, for the period shown Fertilizers, cement, railway material and coal follow in the order named Northbound there are a number of groups in the "million-ton class" Mineral oils, vegetable oils (soybean, copra, linseed), cereals (wheat, rice), textile material (jute, cotton) and minerals (manganese, tin) are five such groups which together account for about one half of the whole movement

Passenger traffic through Suez is of more than ordinary interest since passengers pay a toll charge Normally, the number averages a little less than

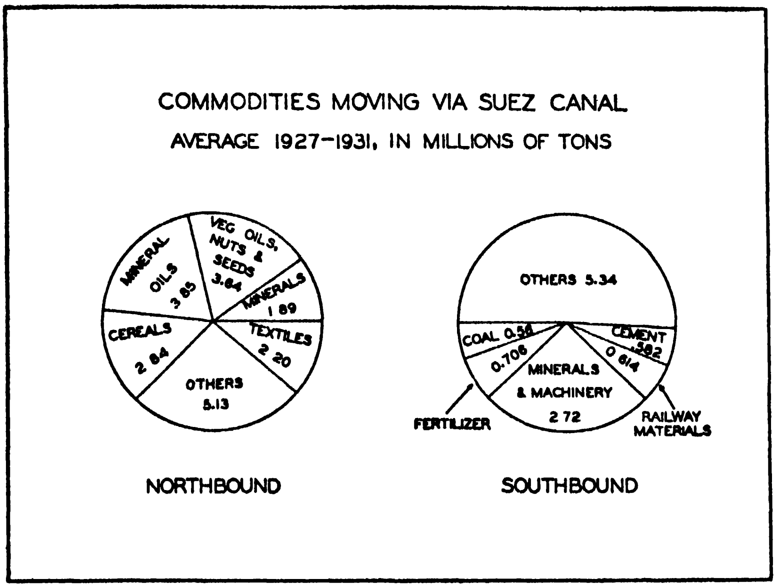

FIG. 4 AN ANALYSIS OF CANAL TRAFFIC

300,000 per year, but in 1936 the Ethiopean conflict sent an extra half-million soldiers and workmen through at $2.00 each. The revenue from passenger movement normally yields about $750,000 annually.

Of the regions most affected during a normal year, e.g., 1934, the relative importance of those east of Suez is shown in Fig. 5. India and the Far East are seen to be about equal and together account for about one half of the total. The Persian Gulf, Australia and the Singapore regions follow in that order. Since 1934 conditions have been very abnormal. The Italian-Ethiopian struggle stimulated the movement of both cargo and passengers to the Red Sea ports, while the oil boom increased the importance of the Persian Gulf.

The phenomenal growth of the canal's business, the vital character of many of its services and the varied and widely scattered interests which are concerned with its use have inevitably led to a multitude of problems—strategic and political—as well as economic.

The canal is owned and operated by a private stock company with a franchise from the Egyptian Government — an agreement having some thirty years still to run. The shareholders are almost entirely French investors and the British Government. Because the rules of the company limit the maximum number of votes of any stockholder to ten, irrespective of the number of shares he possesses, the actual administration of the company's affairs is in the hands of the French, who have nineteen of the thirty-two directors. The responsibility for the defense of the canal has been gradually taken over by the British. The enormous revenue is derived from tolls which are paid, of course, by the whole shipping world.

The canal was built against the advice of the best English engineers and in spite of the vigorous opposition of English statesmen. Yet when once completed and in actual operation, England recognized its value as a short-cut to her eastern empire and seized the first opportunity to purchase a large block of the stock. Her political and military policies in Palestine, in Trans-Jordan, at

Aden and in Egypt have been actuated by her desire to safeguard her communications through the canal

England's assumption of the position of military guardian of the canal has given rise to fears by other nations that she might, on occasion, use it as a powerful military weapon During the Italo-Ethiopian struggle, for example, there was a wide-spread demand made for her to close the canal to Italian shipping Even the suggestion of such action was sufficient to prompt Mussolini to demand a share in the canal's control—a demand made with more fervor inasmuch as his treasury had just paid many millions in tolls in connection with Italy's African campaign

It would seem, however, that in a major European war the strategic importance of Suez has declined—at least for merchant shipping Modern aircraft and submarines have made the Mediterranean so hazardous that during such a war most merchant vessels have been diverted via Good Hope During the World War about one half of the losses of British shipping occurred in the Mediterranean and that was when both France and Italy were allies and all the rest neutral, except Austria, Bulgaria and Turkey. During the present struggle, the Mediterranean is reported to be practically closed, British ships being advised to use the Cape route

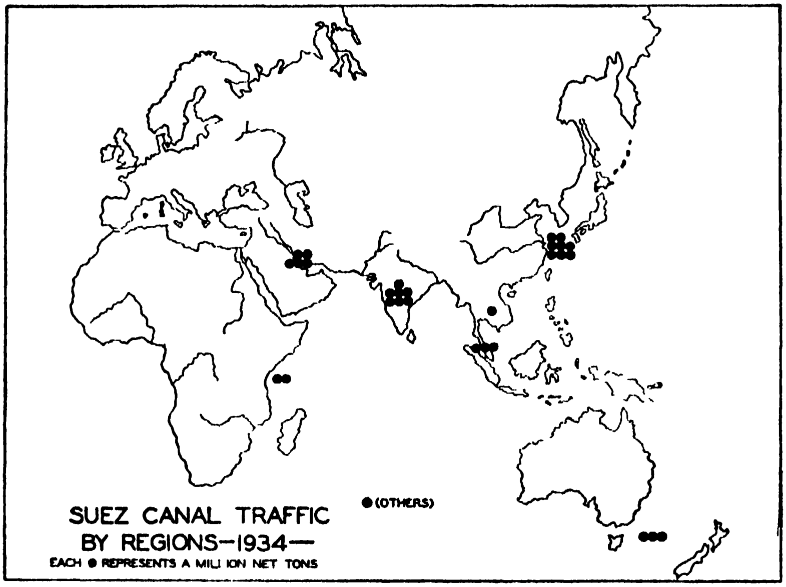

FIG 5 RELATIVE IMPORTANCE OF REGIONS AFFECTED BY SUEZ

The chief criticism of the Canal Company, however, is against the exorbitant tolls Sir Arnold Wilson[1] estimates that the Suez charges amount to an average levy of about 3 per cent on the value of cargo For cheap merchandise, *e g*, East African sisal, it may be as much as 30 per cent As a consequence, English goods in the Indian Ocean have been seriously handicapped in competition with those of Japan

Shippers naturally cite the case of the Panama Canal to support their charges The latter cost about two and a half times as much as the Suez waterway, and the maintenance expense of the two is in about the same ratio However, Suez

[1] Sir Arnold Wilson, "The Suez Canal, Its Past, Present and Future," 1933.

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FIG. 6. CONTINUAL DREDGING TAKES PLACE

THE CANAL DEPTH IS SUFFICIENT FOR ALL SHIPS EXCEPT A FEW OF THE VERY LARGE PASSENGER LINERS. THESE KEEP THE DREDGES WORKING OVERTIME.

Courtesy British Air Force

FIG. 7. FAN-LIKE DEPOSITS OF THE DREDGES

DRIFTING SAND IS PREVENTED FROM REFILLING THE CANAL EXCAVATION. CANAL STATION IS SEEN HERE IN THE CENTER.

rules for ship measurement result in much higher figures than do those of Panama, and, in addition, their regulations regarding ballast are such that while tankers may frequently go in ballast, with reduced tolls, only a few freighters can so qualify, and passenger ships and troop ships almost never. Finally, Suez tolls must be paid in gold—a provision which bears heavily upon countries which have gone off the gold standard. As a result, Suez tolls are from 20 to 30 per cent. higher per net ton, or 40 per cent. higher per ton of cargo, than those of Panama.

The Canal Company, feeling secure in its monopoly privileges, has for the most part chosen to ignore the demands of the shippers. It has improved and modernized the facilities, yet reductions in tolls have been small. "Dividends—bigger and bigger"—may well be its slogan, and charges have been maintained "as high as the traffic can bear." As a consequence, the stockholders have grown rich, while complaints from shippers have been loud and long. Dividends for the past three years have been over 50 per cent. and for the past half-century have never been less than 25 per cent. By 1932, total dividend payments had repaid the original investment over 45 times. Since the World War, it is estimated that one sixth of the receipts would have provided fair dividends and a liberal sinking fund. Directors of the company hold office for life, draw about $17,000 a year and do little in return.

It has been well said that "much is rotten at Suez and the waters of the canal are muddy in more than a physical sense." A thorough overhauling of the management of the waterway is long over-due, an intolerable situation has been developing and growing resentment bids fair to force a change. Suez has become more than a mere waterway. It is an international public utility, and as such the suggestion that it should be taken over and operated by a committee of European nations would seem to have merit.

MANAGEMENT OF AQUATIC WILDLIFE IN THE GREAT BASIN

By Dr. ANGUS M. WOODBURY
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MANAGEMENT of aquatic wildlife under climatic conditions of the Great Basin is largely a problem of management of water—the chief environment, even though the basic problem may be one of land use Such a problem is particularly complex in the Great Basin, lying as it does between the Sierra Nevada Range of California and the Wasatch and Uintah Ranges of Utah, the former extracting much of the moisture from the Pacific winds, thereby leaving a semi-arid interior with scanty rainfall—5 to 20 inches The Wasatch Range, rising 5,000 to 8,000 feet above this interior basal plain draws many times as much moisture from the passing winds—20 to 60 inches The 500-mile floor of the basin at 4,000 to 6,000 feet altitude is broken by numerous smaller parallel north-south ranges rising from 1,000 to 5,000 feet above the floor

These lesser ranges draw precipitation approximately proportional to their altitude, increasing about one inch for each 160 to 200 feet rise Such mountains produce minor streams of water which mostly disappear in the desert The main run-off streams come from the Sierra, Uintah and the Wasatch Mountains, collecting in two separate basins, which formed in Pleistocene times two huge lakes—Bonneville of Utah and Lahontan of western Nevada

Lake Bonneville, formerly 300 miles long and 1,000 feet deep, drained out through Red Rock Pass of southern Idaho into the Columbia River drainage via the Snake River

Degrading its bed through the pass, it left two principal shorelines, the Bonneville Terrace at the top and the Provo Terrace about 375 feet lower, where the degrading was halted by a hard rock stratum in the pass. With lessened moisture supply, this lake was further reduced by evaporation, leaving the Great Salt Lake as its principal remnant and several other remnants of lesser size

Similarly, Winnemucca and Pyramid lakes in Nevada are the principal remnants of Lake Lahontan, but in contrast with Great Salt Lake these lakes have been fresh enough to support one of the world's largest trout, *Salmo henshawi*, although in recent times diversion of inflowing water has so reduced the size of the lakes and so concentrated the salt in them as to eliminate trout from Winnemucca Lake and threaten extinction of this unique species from Pyramid Lake The salt accumulations in these lakes, however, will probably never equal that of Great Salt Lake, since the inflowing waters drain non-marine and igneous rock formations, whereas those of Great Salt Lake drain marine sediments with heavy salt concentrations

The problem of water management begins with falling raindrops and snowflakes and increases in complexity with each successive step of water movement. Snow falling in the winter accumulates in greater quantities and for longer periods at successively higher altitudes, acting as storage reservoirs that release their pent-up waters with the increasing temperatures of spring and early summer In a few cases, perpetual snow banks or incipient glaciers remain throughout the summer

The water from melting snows or rains may be absorbed in the ground up to the

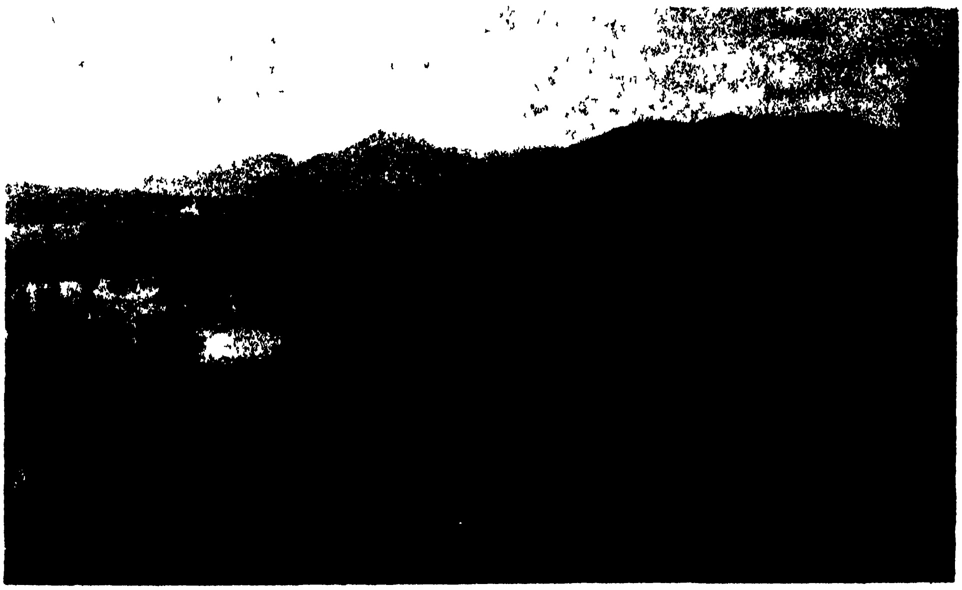
GILBERT'S MAP OF OLD LAKE BONNEVILLE
SHOWING ITS FORMER OUTLINE AND DRAINAGE AND ITS PRESENT REMNANTS IN SEVIER AND GREAT SALT LAKES PHOTO BY UNIVERSITY OF UTAH

holding capacity of the soil, beyond which it will run off or evaporate. Absorbing capacity of the soil depends upon several factors such as rate, slope, texture and aspect, but chiefly, according to Forest Service investigations, upon the presence of living or dead organic matter either in or on the soil. The greater the organic material, the more water is held before run-off occurs.

The percolating soil waters serve as second-line reservoirs from which the retarded waters tend to emerge farther down the mountain slopes as springs and form the sources of permanent streams and lakes that are more or less constant. Thus the surplus water from intermittent rains and snows of the higher mountains are by means of snow and soil storage transformed into perennial streams that flow into the lower altitudes, where rainfall does not equal evaporation. They flow into the basin depressions where, barring human interference, they accumulate until evaporation offsets the inflow.

Every step in the downward progress of the water from mountain peak to basin bottom is affected by variations in temperature, light, soil, soluble minerals, topography, aspect and other factors of the environment. The accumulated differences produce striking contrasts in habitats to which the wildlife must adjust.

In the glaciated mountain tops, snow-fed cold-water lakes, with little dissolved mineral matter and high oxygen content, provide a meager food base of algae, worms, mollusks, crustaceans and insects, culminating in crops of trout which serve as sources of fishing for ospreys and mankind.



SAMPLING STREAM BED FOR FISH FOOD ORGANISMS[1]
IN THE GREAT SALT LAKE BASIN. U. S. BUREAU OF FISHERIES

The swift, well-aerated mountain streams descending the steep slopes tend to increase the mineral content and temperature as they descend toward the valleys. The aquatic life which would persist must be prepared to resist the driving force of the current by swimming or clinging or else avoid the current by other means. Trout, water ouzels, king-

[1] Photographs not credited are reproduced by the courtesy of the U. S. Forest Service.

fishers, mink and beaver are the chief vertebrates involved

As the streams reach the valleys the gradient is gradually reduced, thus slowing the streams, the rocky bed gives way to gravel and sand, the mineral content increases and the waters get warmer Coalescing with others, they tend to form slow or sluggish warm-water streams before they empty into the basin depressions The species of algae and invertebrates change and the trout are replaced by warmer-water fishes

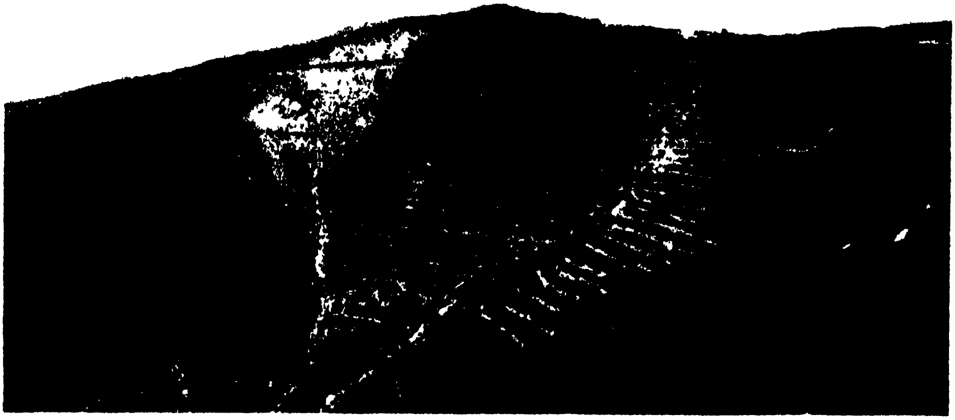
The Great Salt Lake, with its saline content approaching saturation, presents a hostile environment to most living organisms, although a few algae, a brine shrimp (*Artemia gracilis*) and two brine flies (*Ephydra gracilis* and *E. hians*) are able to meet the physiological exactions imposed in order to extract moisture from the salt solution, and some island-nesting birds find suitable rookery sites on the secluded islands of the lake.

In the Great Salt Lake drainage basin, the higher mountains (8,000 to 11,000 feet) bear spruce-fir forests, except where higher mountain peaks rear their snow-clad summits above timber line These forests aid the storage of snow by holding and shading, thus delaying the melting period They also provide litter and humus for the soil, which increase the absorbing capacity of the soil and add to the underground water supply for springs

MOUNTAIN PEAKS STORE SNOW
WHICH REMAINS MUCH LONGER THAN THAT WHICH FALLS ON LOWER SLOPES AND VALLEYS

The valley lakes and ponds vary from fresh, well-oxygenated water suitable for trout through various stages of stagnancy and brackishness to the saturated solution of salt sometimes found in Great Salt Lake The intermediate stages provide suitable habitats for muskrats, for plant and invertebrate foods of waterfowl and for the so-called "trash fish" (carp, chubs and suckers) that furnish a prolific source of food for the fish-eating birds (pelicans, cormorants and herons)

The lower mountain slopes (6,000 to 8,000 feet) are robed with deciduous chaparral—mostly oak brush—a prolific



TERRACING OF CANYON HEADS
THIS HAS PROVED EFFECTIVE IN PREVENTING RUN OFF AND STOPPING EROSION

source of forage for summer live-stock grazing The foothill slopes (5,000 to 7,000 feet) generally bear pigmy forests of juniper and piñon pine, widely spaced with root systems several times as large as crowns The open, well-drained valleys (5,000 to 6,000 feet) usually bear stands of deep-rooted sagebrush, except where replaced by human agriculture In the lower salty soils (4,200 to 5,000 feet), shadscale, *Kochia* and greasewood replace the sage except in the extreme salt desert, where it is barren

Each step in the descent of the water

PLANTING FISH FRY IN STREAM NEAR CACHE NATIONAL FOREST, UTAH.

Courtesy of J E Broaddus

BIRDS OVER GREAT SALT LAKE, PHOTOGRAPHED FROM THE STERN OF A BOAT

from mountain peak to Great Salt Lake is beset with human use, interference or management The spruce-fir forests are cut for timber All the plant formations are grazed by domestic live stock Practically all mountain lakes and mountain streams and many of the valley lakes and streams are fished for sport and recreation Water is diverted from streams for irrigation, water power, manufacturing, culinary use, mining and other purposes Storage reservoirs are constructed and lakes are impounded in efforts to regulate stream flow Dykes are made and lands flooded to make ponds for water-fowl and fur-bearers Other ponds and swamps are drained for mosquito control Some lakes are lowered by pumping for irrigation or power

Most of these diverse interests change or manipulate the natural flow of the streams in one way or another Most of the larger streams have similar flow characteristics, i e , the hydrographs have similar curve patterns The basic flow derived from springs is fairly constant from July to April, but the melting snows of spring add to the basic flow and produce a marked rise of about 40 to 150 per cent from April to July, with a peak during May or June In addition, sudden floods of irregular dimensions at uncertain times during the cloudburst period from July to mid-September produce sharp peaks in the hydrograph

It seems generally agreed among those interested in wildlife management that maintenance of constant water level in stream or lake is a desirable goal and that deviations therefrom are detrimental to wildlife This has a biological basis because of the consequent crowding into smaller space and resultant reduction in oxygen content and because the

DISTRIBUTION OF RAINBOW TROUT
TANKS WITH CONSTANT AERATION EQUIPMENT MOUNTED ON A TRUCK FURNISH AN EFFICIENT METHOD OF TRANSPORTING FISH TO LAKES AND STREAMS

RESULTS OF THE FLUCTUATIONS OF A RESERVOIR

AN UGLY BARE AREA IS LEFT AND THE AQUATIC WILD LIFE IS CONCENTRATED IN THE WATER REMNANT AT THE BOTTOM, WHEN THE RESERVOIR IS LOW

living organisms of the fluctuating zone are subjected to such diverse aquatic and terrestrial conditions that few organisms can survive River flood plains, storage reservoirs and the impounded portions of lakes are generally barren because of the fluctuations Obviously, then, anything which tends to reduce the fluctuating zone will tend toward increased stabilization of wildlife

Any plans looking toward stabilization of water level must take into consideration the diverse interests in control of the water Custom and law give irrigation and culinary use preferential right to water Canal diversions reduce the stream or dry it entirely below the point of diversion, although a part of the diverted water eventually finds its way back into the lower stream channels via underground seepage In addition to the loss of fish habitats from the diverted stream bed, the danger of fish loss by stranding in the irrigated fields presents a problem of fish screens at the diversion dams.

Storage reservoirs for irrigation aggravate the fluctuation problems Normally, storage exceeds withdrawal from the reservoir from October to April, but withdrawal exceeds storage from May to September, thus producing an annual cycle—empty in the fall and full in the spring Even though such reservoirs catch the high water of spring and the floods of summer and thus help to regulate lower stream flow, yet the withdrawal of irrigation water during the summer and not in the winter merely shifts the stream fluctuations below the reservoir, but does not essentially alter the difficulties

Water-power diversions reduce or dry streams for short distances, but the water is returned to the stream channel after serving its purpose Such diversions do not otherwise affect the stream flow unless storage is undertaken, in which case the reservoir fluctuates, but the stored water is used to smooth out the fluctuations in the streams

Mine and mill diversions may result

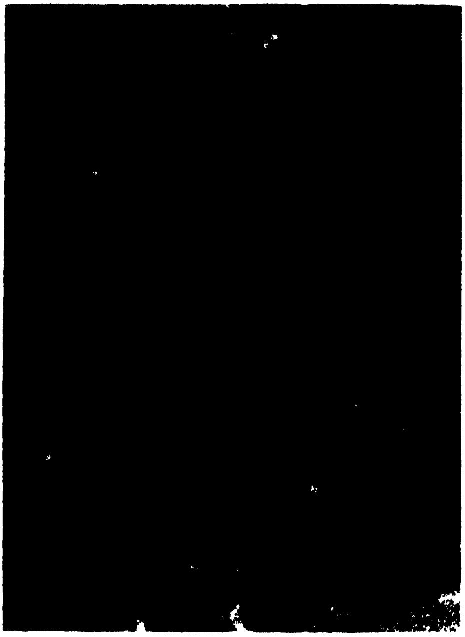
Courtesy of U S Biological Survey

ANTELOPE TAKING A DRINK IN THE CHARLES SHELDON REFUGE, NEVADA

in bringing silt or chemical washings into the stream with the returning water, but in many cases artificial settling ponds are interposed before the water returns Such silt, if it enters the stream, because of its covering and scouring action tends to eliminate fish foods and otherwise make the stream unsuitable for fish

One of the most critical factors affecting stream-flow fluctuations is the serious depletion of vegetative cover on the stream watersheds, due principally to overgrazing but also to lesser causes of fire, snowslides and over-cutting of timber, discussion of which does not properly belong here Depletion of the vegetative cover, however, reducing the absorbing capacity of the soil, makes bigger floods and higher water in the spring and consequently lessens the storage of water in the soil for the permanent streams, *i e*, it tends to greatly accentuate the fluctuations The resulting erosion is disastrous not only to aquatic wildlife but also to crops, live stock, canals and reservoirs

Those interested in wildlife management have but little control over such practices Their problem is to make the best of a bad situation, and they are faced with several serious questions First is the fish problem The great demand for fishing privileges invites management for the maximum production of fish in suitable waters The state and the Federal Government under cooperative agreement have both undertaken artificial fish culture as a partial answer to the problem. Fish-cultural practices are beset with further problems suitable waters as to temperature, gases and mineral content, diseases, diet, life history, care and time of planting, each one of which presents a study of its own But after the fish are reared, the question of stream stocking presents itself where, when, how many and what size to plant In actual administration, these questions have had to be decided by guess or political pressure A few years ago, the U S Bureau of Fisheries and the U S Forest Service initiated extensive stream surveys to study the biological potentialities



GREAT CONCENTRATION OF FISH
AFTER UNLOADING IN SMALL STREAM. ALL THESE COULD NOT POSSIBLY SURVIVE, INDICATING THE PROBLEM INVOLVED IN STREAM STOCKING PLANS

PELICANS ON BIRD ISLAND
GREAT SALT LAKE, UTAH

of the streams and lakes as a basis for management plans and further studies.

Out of these surveys came recommendations for stream improvements and stream stocking, the former designed to provide pools, shelter, shade, spawning areas and better food supply. Some forty miles of experimental stream improvements were undertaken in Utah in 1934–35. Later checking on the results has indicated that even though properly located dams and deflectors were valuable in producing more pools and ponds with greater surfaces and better food, yet floods have played havoc in certain places, filling pools, undermining banks and removing protective structures, especially in the mountain streams. This indicates the need for flood and erosion control farther upstream before such improvements can be fully successful.

The U. S. Forest Service studies have indicated that the most effective flood and erosion control is dense vegetation. On denuded lands seriously eroding areas may be checked by the contour trench system, beginning at the watershed divide and working down, in conjunction with rehabilitation of the plant cover. However, it is not economically feasible to handle an entire watershed by this method alone, but it should be supplemented by proper control of grazing of live stock and big game.

In some administrative study experiments on four barren mountain lakes, the Forest Service attempted to increase the plant foods for fish by adding limestone and phosphate rock to the water. Although some temporary increase was noted the first season, due no doubt to the increased mineral content of the water, the effect seems to have been reduced thereafter, probably as a result of the great quantity of water passing through the lakes.

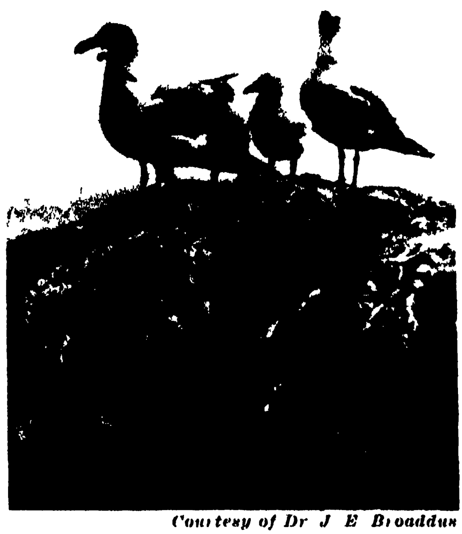
Efforts have been made to induce the power and irrigation companies so to regulate their reservoirs and lakes that

there will be a minimum line below which no water will be withdrawn, the reserve to serve as a nucleus from which both food and fish can expand as the water again increases Despite good intentions, the economic pressure during drouth years is so great that the necessary reserves are not always maintained. As a result there is a growing tendency in planning new reservoirs so to design the outlets as to provide an automatic reserve for wildlife and recreation purposes

The second great problem is that of waterfowl The enormous reduction in American waterfowl has concentrated attention upon management, in the hope of preventing further decreases Because of the huge concentration of waterfowl in the valley waters of the Great Salt Lake Basin, it is of critical importance in national and international management plans to provide feeding, resting and breeding areas It has been demonstrated that the natural areas can be greatly improved and enlarged by artificial distribution and impounding of the water Private clubs, the Federal Government and the state of Utah have all taken part in developing new flooded areas for this purpose Around the shores of Great Salt Lake, the strategy has been to impound the waste waters by levees or dykes and make it do extra duty before entering the briny water of the lake

The federal project under control of the U S Biological Survey at the mouth of Bear River floods nearly 30,000 acres in five units above the dykes and nearly 20,000 acres below the dykes by spreading out the overflow surplus water Here again, the fluctuation problem presents itself During late summer, there is not always enough water to offset evaporation from the five units, hence in late spring, they are filled to capacity and the summer water is used to keep them as nearly constant as possible In extreme drouth years, unit number four

BEAVERS AID IN WATER MANAGEMENT
PROVE TO BE EFFECTIVE AGENTS IN HOLDING BACK RUNNING WATER IN NUMEROUS SMALL RESERVOIRS AND HELP TO STABILIZE THE WATER FLOW



Courtesy of Dr J E Broaddus

SEA GULLS, GREAT SALT LAKE SHORE

Courtesy of Utah Fish and Game Department

UINTAH MOUNTAINS—ONE OF OUR LARGEST PRIMITIVE AREAS

ONLY TRAILS LEAD ONE TO INNERMOST PARTS. CONIFEROUS FORESTS AT HIGH ALTITUDES AND THE ALPINE TUNDRA ABOVE TIMBER LINE, STORE MUCH WINTER SNOW AND THE RESULTING WATER IS RELEASED IN THE SPRING WHEN THE LOW VALLEYS ARE SWELTERING IN HEAT.

has been sacrificed and allowed to go dry in order to provide sufficient water for the others Now proposals are being made to provide reservoir storage farther upstream to take care of the water deficiency.

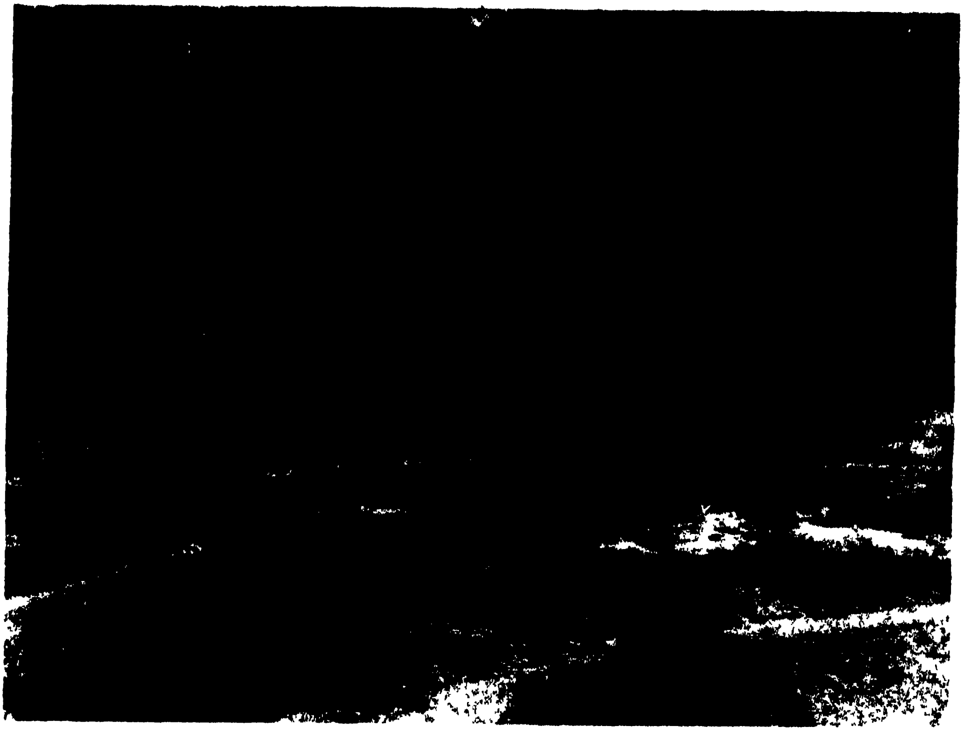
How much and in what way the drying of unit four and of lands below the dyke affects the food supply is an interesting problem that needs further study It has been noted that great concentrations of birds occur on these areas when they are again flooded and that the pondweed (Potamogeton) is not killed but recuperates readily when again supplied with water There is little doubt that the supply of waterfowl foods has been increased enormously on the project as a whole, but further studies of food habits are now being undertaken to provide a basis for management plans

The duck sickness is still a baffling problem, despite the claim of specialists that lead poisoning from eating shot can be distinguished from the real duck sickness by botulinus poisoning With the discovery that one or two shot pellets picked up by waterfowl will produce severe sickness or death has come a realization that every shell fired by hunters in a marsh is a potential menace to the life and health of many birds for years to come The shell manufacturers have the problem of finding harmless substitutes

STREAM IMPROVEMENT WORK

MUCH OF THE WORK WAS RUINED BY FLOODS, INDICATING FURTHER NECESSITY FOR EROSION CONTROL ON THE WATERSHEDS

Despite the old theory that fresh-water flooding of the alkaline flats would eliminate the duck sickness, occasional outbreaks still occur Investigations have recently been undertaken to establish the origin and distribution of the causes of such outbreaks The problem is complicated by the fact that the birds may pick up the poison at one place and become affected by it at some distant place, such as the dykes at the refuge Further in-



Courtesy of W. H. Schaffer

A TYPICAL BEAVER DAM LOCATED AT GRANITE CREEK

vestigations by the Biological Survey in the region include studies of nesting and feeding concentrations, bird movements and airplane census estimates, the latter about 25 times per year.

Some years ago, in response to competition of private duck clubs, the state of Utah developed public shooting grounds a few miles north of the Bear River Refuge. More recently, in response to the waterfowl shortage, attention has been directed to developing reflooding projects with the avowed intention of reserving at least half of the area for sanctuaries, the other half to be open to hunting. These projects include the following in various stages of development: Locomotive Springs, Farmington Bay, Clear Lake and the mouth of Weber River. Still more recently, an experimental mallard breeding ground has been developed in the Bullock Slough near Provo, Utah, in an effort to increase the breeding of this duck under protection.

The third great problem is that of aquatic fur-bearers—beavers and mink on the higher streams and muskrats in the valley waters, neither one of which has been able to maintain adequate numbers under public control largely because of opposition by irrigation interests and because of poaching. Certain private fur farms have been able to make muskrats profitable. By comparison with early-day trapping operations and the streams suitable for beaver propagation, it is estimated that the beaver population of today is less than 10 per cent of its potentialities. Here, then, is another challenge to management. The U. S. Forest Service and the state of Utah are cooperating in an effort to develop a large population by trapping and redistributing the beaver under the protection of private

TYPICAL EXAMPLE OF EXPERIMENTAL WORK
TO PROVIDE POOLS, FALLS AND HOLES

individuals with special trapping permits The question has arisen if it is not a shortsighted policy on the part of the irrigationist to object to beaver ponds on the headwaters of the irrigation streams Will not the ponds help to store more underground water that will in the long run tend to produce more summer water?

A fourth problem is that of mosquito control in its relation to management of wildlife The initiative was taken in Salt Lake City, where the nearby mosquito breeding swamps have been drained, thereby eliminating the aquatic habitats for fish and waterfowl The policy seems to be, however, to save the duck clubs a little farther away and so regulate them as to prevent or reduce the water fluctuations Special studies have been made of sources of various species, special oils suitable for a desert region and the use of native minnows and Gambusia as aids in control It is a paradox on management, however, to see areas side by side, one being flooded for wildlife, the other being drained for mosquito control

A fifth problem is the protection of fish-eating birds, some of which nest in rookeries on the islands of Great Salt Lake They have in the past been severely persecuted because of their fish-eating propensities, but it is becoming more and more apparent that they feed largely upon the "trash fish" some of which compete with ducks for plant foods The help of these birds in controlling the fish numbers in the reflooded waterfowl refuges is becoming recognized in some quarters

A further aspect of this problem has appeared during the recent drouth The water of Great Salt Lake had become so reduced by evaporation that it reached saturation in 1934 The precipitation of salt during the summers of 1934–5–6 was

Courtesy of Leon Stanley

SALT DEPOSITS ON BOAT IN GREAT SALT LAKE

PROBABLY DUE TO THE SMALLER SIZE OF THE LAKE IN THE DROUTH CYCLE AND THE CONSEQUENT CONCENTRATION OF SALT

concurrent with the near-disappearance of the brine flies from the lake, whereas the brine shrimp persisted, although they may have been reduced in numbers Apparently the brine flies returned in 1937 It has been suggested by observers on the lake that probably the salt crystals buried the fly eggs or pupae of summer, but failed to affect the shrimp eggs of winter Weak, dying and dead pelicans have been observed with salt crystals on their feathers, suggesting that they had been trapped and doomed by the crystallizing salt which prevented them from flying It is reported that a party of boatmen captured some of these pelicans, soaked off the crystals in fresh water, fed them and found they were so recuperated they could fly away

A sixth problem is the question of pollution falling into three principal categories organic decomposition reducing the oxygen content, chemical poisons from mills and factories, and mechanical irritants such as sawdust and silt Outbreaks of dying fish have been traced to beet-pulp wastes from sugar factories and a case of pea-silage pollution has been reported Such pollutions are, of course, more or less unusual and accidental The potential menace to fish from sawdust by mechanical clogging of the gills or changing the pH of the water by resin is mostly avoided temporarily by storing fresh sawdust at the sawmills, but the danger of being washed into the stream by high water or floods persists for a long time thereafter

A peculiar problem, closely related to chemical poisoning, has been represented by certain recent attempts at controlling snails that act as alternate host for livestock liver fluke parasites by means of copper sulfate An experiment of the Bureau of Fisheries indicated that if the copper sulfate was applied in sufficient concentration to kill snails, it also killed algae, worms and trout

In face of all these wildlife problems, there is still a more basic question for the general public to answer What shall be done about our natural resources to stop abuses and exploitations and place them on a sustained yield basis?

DEVELOPMENT AND MANUFACTURE OF OPTICAL GLASS IN AMERICA

By M. HERBERT EISENHART AND EVERETT W MELSON
BAUSCH AND LOMB OPTICAL COMPANY

ALTHOUGH the production of optical glass in the United States is often attributed to the World War, in which it was one of the vital materials, it would be more appropriate to say that the war merely created a forced draft under furnaces even then bright with the flames of experiment, for its production in the United States was inevitable The importation of ophthalmic crown glass from abroad had reached such proportions that the leaders in the optical industry could no longer ignore the desirability of home production

War, however, makes immediate and extreme demands In the case of optical glass, a mere comparison between the Civil War and the World War will serve to explain the demand In the conflict between the North and the South, artillery was fired at point-blank ranges The enemy was visible, and distance was estimated with the naked eye, but the power and precision of modern guns have been so improved that relatively small targets may be attacked at ranges beyond 25,000 yards Most of the firing is directed at objects either below the horizon or obscured by intervening obstacles, but whose position has been located either by land or aerial reconnaissance Fire control thus becomes an engineering problem requiring precise instruments, and the effectiveness of modern artillery and, indeed, of the army and the navy, depend greatly on the quality and quantity of these instruments

In March, 1917, when the imminence of our entry into the war was apparent, the Naval Consulting Board disclosed the critical situation in respect to optical glass Imported stocks were at the vanishing point, and there was no possibility of replenishment from abroad This glass, the most refined product of the glassmaker's art, was inherently a secret process confined chiefly to one firm in Germany, one in France and one in England In each country it was either a government monopoly or enjoyed a subsidy The fact that all imports of optical glass into the United States came in duty-free increased our dependence on these sources

In this emergency, the government, through the Council of National Defense, sought the aid of the Geophysical Laboratory of the Carnegie Institution, whose research laboratory had been engaged for many years in the study of silicate solutions similar to optical glass Dr Arthur L Day, director of the laboratory, began an immediate survey of the country's facilities Dr F E Wright headed a group of scientists which was assigned to the Bausch and Lomb plant in April, 1917

Here the pioneer efforts of William Bausch, begun in 1912, had resulted in the production of two types of optical glass, but much remained to be done The government required 2,000 pounds of optical glass per day, whereas 2,000 pounds per month was about the total to be expected from the one producing plant and from the experimental plants of the Bureau of Standards, Keuffel and Esser, Pittsburgh Plate Glass Company and the Spencer Lens Company

Military optical instruments are for

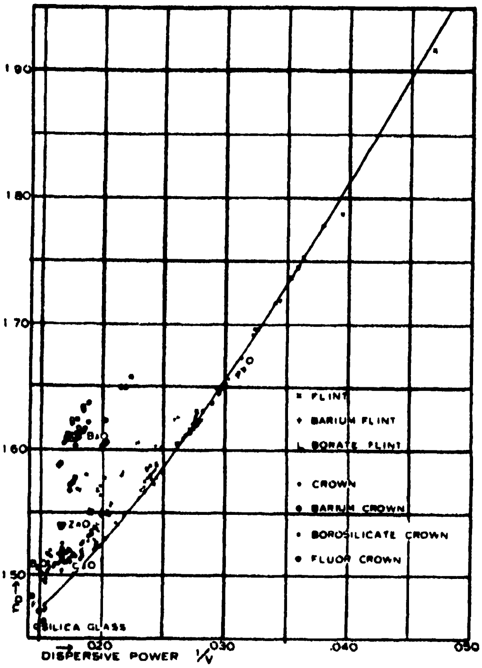


FIG. 1. DISPERSIVE POWERS OF A SERIES OF OPTICAL GLASSES ARE PLOTTED AGAINST THEIR REFRACTIVE INDICES. AFTER WRIGHT.

the most part telescopes or instruments related to telescopes, and experience has shown that from three to five different types of glasses are required in their design. The problem was to perfect a few types of glasses, such as ordinary crown, borosilicate crown, light and dense barium crown and light and dense flint, rather than to develop entirely new types.

War-time efforts in the field of optical glass production were, therefore, concentrated on the problem of producing these few essential types of optical glass, and facilities were developed adequate to meet our needs.

At the close of the war the demand for optical glass was reduced to a very small part of the war-time requirement, and much of the productive capacity of the country was abandoned. The production of optical glass, however, was continued by the Bausch and Lomb Optical Company and at the plant of the Bureau of Standards.

In order to meet the requirements for photographic lenses and microscope objectives, many new types of glass remained to be developed. These have gradually been added to the list produced during the war until at the present time the United States is absolutely independent in so far as concerns the production of all essential types of glass, as well as in the production of the raw materials from which the glass is made.

Limitations of the Old Glasses

While little is known to-day of the constitution of glass, even less was known at the close of the World War. However, analysis of the available types of glass did afford some knowledge of the properties of the final product.

Except for the early attempts of Fraunhofer and the later work of Harcourt and Stokes, no effort was made to break the uniform monotony of crowns and flints until Abbe and Schott joined hands in 1862, although Dolland's achromatic telescope objectives had indicated the need for new types.

It was Abbe's discussion of the limitations placed on the design of refracting instruments by the limited number of optical glasses which outlined the research to be attempted. Beyond silicic acid, alkali, lime and lead, scarcely any substances had been tried except perhaps alumina and thallium. The problem was to produce crown and flint pairs with as nearly as possible proportional dispersion throughout the different sections of the spectrum, in order to afford a higher degree of achromatism than the old glasses, thus diminishing the strong secondary spectrum, and to attain a greater diversity in the two chief constants—mean index and mean dispersion. Because of the uniformity of their chemical constituents, the old silicate glasses could be arranged as a single series in which,

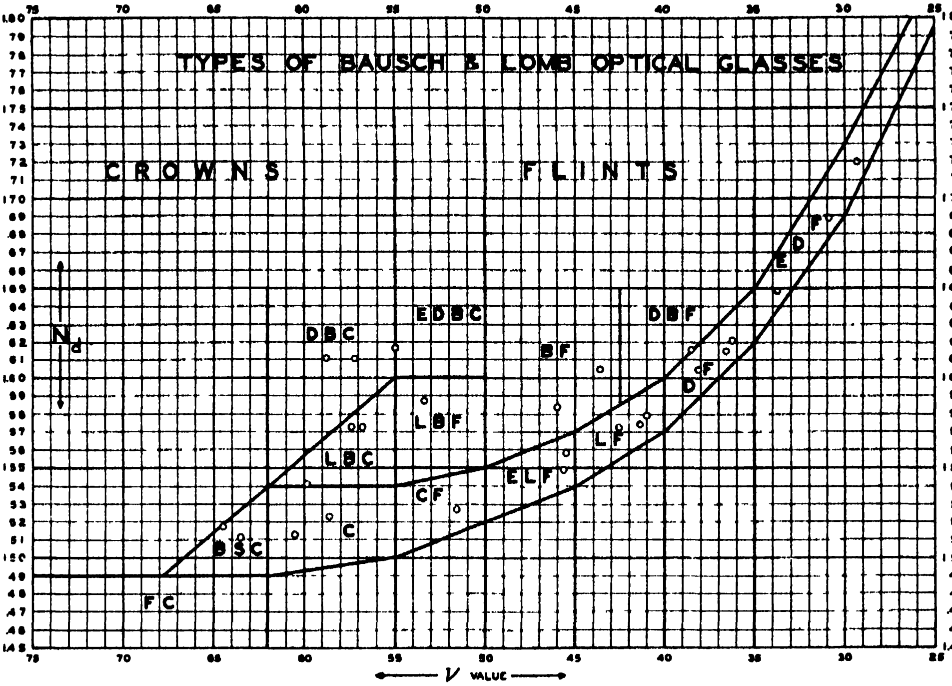


FIG 2 RATIO OF REFRACTIVE INDEX TO DISPERSIVE POWER IN VARIOUS TYPES OF GLASSES

FC	Fluor Crown
BSC	Borosilicate Crown
DBC	Dense Barium Crown
LBC	Light Barium Crown
C	Crown
EDBF	Extra Dense Barium Crown
LBF	Light Barium Flint
CF	Crown Flint
BF	Barium Flint
ELF	Extra Light Flint
LF	Light Flint
DBF	Dense Barium Flint
DF	Dense Flint
EDF	Extra Dense Flint

from the highest crown to the densest flint, the dispersion steadily increased with refractive index

The effort to break the linear relation of the old glasses required the introduction of many new elements and created many difficulties The flux must not act upon the material of the crucible and so absorb impurities Elements which evaporated during the melting process, tending to produce "veins," had to be discarded The glass must be brought from the plastic to the solid state without producing strain In the operations of melting, cooling and subsequent reheating extreme care was necessary to avoid cloudiness, crystallization and bubbles Further, the glass must be colorless, strong enough to withstand grinding and polishing and untarnishable

Properties Sought in New Glasses

Beginning with phosphoric and boric acids as the glassmaking oxides, such elements as boron, phosphorus, lithium, magnesium, zinc, antimony, cerium, didymium, erbium, silver, mercury, thallium, bismuth, uranium and fluorine were introduced in definite percentages It was soon evident that by the introduction of some of these new elements at least one desired object could be achieved, namely, variation of the hitherto fixed relation

between refractive index and dispersion. Few of these elements, however, were of use in producing a greater similarity between the dispersions of crown and flint.

With the use of boron and barium as the glass-making oxides the relation between refractive index and mean dispersion was radically altered. Boric acid is customarily used in flint glasses for shortening the secondary spectrum, since it has the effect of lengthening the red

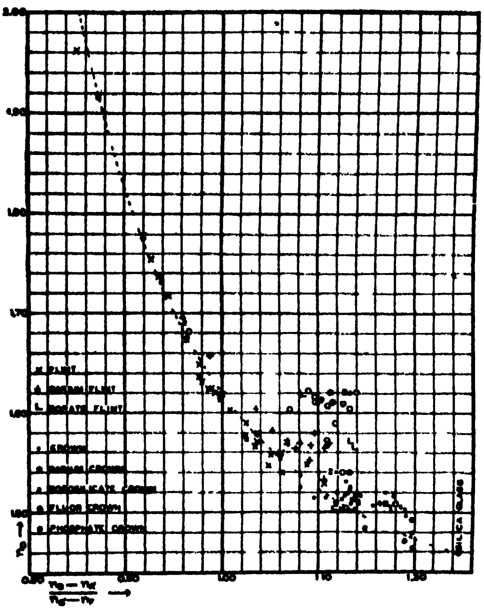


FIG. 3. THE RATIO $(N_D - N_{A'})/(N_{G'} - N_F)$, WHICH IN EFFECT EXPRESSES THE LENGTH OF THE RED END OF THE SPECTRUM TO THAT OF THE BLUE, IS PLOTTED AGAINST THE REFRACTIVE INDEX, N_D, FOR A SERIES OF VARIED OPTICAL GLASSES AFTER WRIGHT

end of the spectrum relatively to blue. Fluorine, potassium and sodium have the opposite effect. Fluorine was regarded as a desirable element because it achieved two results, lengthening the blue end of the spectrum relatively to red and lessening the dispersion throughout the middle portion of the spectrum, desirable properties for the part played by crown glass.

If the dispersive powers of the new glasses are plotted against the refractive index, as in Figs 1 and 2, the old-type glasses fall on a curved line, but the positions of the new types depart widely from this linear relationship. Beginning with the fluor-crown glasses the length of the red end of the spectrum exceeds that of the blue end relatively more than in any other type, following are the boro-silicate crowns, then the ordinary crowns, the barium crowns, the barium flints and finally the flints in which the relative dispersion of the blue exceeds that of the red end of the spectrum.

It has thus become possible to select glasses differing appreciably in absolute refringence and at the same time to state their relative dispersions in the blue and red parts of the spectrum.

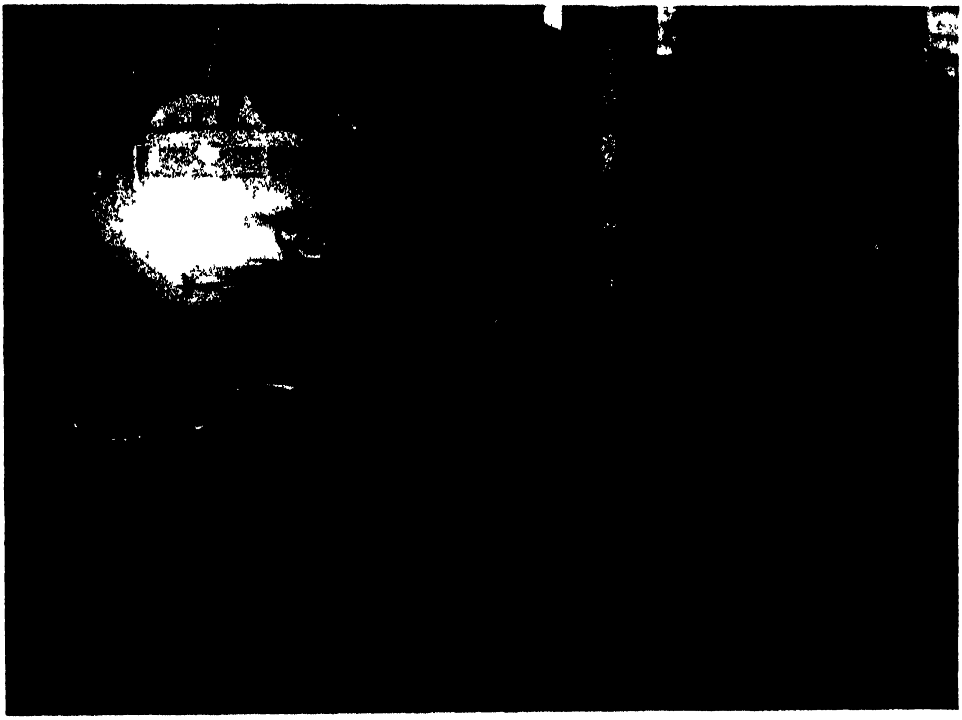
Photo and Micro Objectives Improved by New Glasses

The introduction of new kinds of glass into photographic objectives has made improvement possible in several directions. In the first place, the use of glasses unusually free from color has increased the luminous power of the objective. Then, the similarity of the run of dispersion in the two components of a a doublet has shortened or eliminated the secondary spectrum.

The problem of the simultaneous removal of astigmatism and curvature in the primary and secondary image-surfaces was first solved, though imperfectly, by Miethe's use of phosphate crown and borate flint glasses. In order to obtain anastigmatic flattening, in conjunction with achromatism, it is desirable that the converging lens should have the greater index. This requires that the glass of greater ν should also have the greater n, whereas in the old silicate glasses the rule held that the glass of greater ν had the smaller index of refraction.

The improvement in microscope objectives, due to the new glasses, is apparent, for instance, in the apochromats By the introduction of the new borates and phosphates it became possible to achromatize so that only a tertiary spectrum was left Further, the total dispersion was rendered largely independent of the index It thus became possible to correct axial spherical aberration for two colors This result was most successfully achieved by combining the new glasses with fluorspar In the apochromats the secondary spectrum was abolished and the spherical aberration corrected for two colors This improvement in quality lessened the necessity for the higher power required in achromatic objectives, in which the smallness of the critical amplification prevented the full utilization of large apertures An apochromat affords as much detail as an achromat of larger aperture and shorter focal length

In apochromatic objectives, as in others, the magnification is unequal for different colors, the blue and violet images being larger than the red and yellow This difference of size can be compensated by a suitable eyepiece. It is only necessary to design the eyepiece so that it has an equal difference of magnification but of opposite sign



MECHANICAL STIRRING OPERATION WITH WATER-COOLED STIRRING ROD

What this has accomplished in photomicrography is suggested by the fact that the most intense visual image is produced by rays from near the red end of the spectrum, while the most intense photographic image is produced by rays from near the violet end. An imperfect achromatism between these two groups of rays makes the two images fall in

CENTERING MICROSCOPE OBJECTIVE LENSES

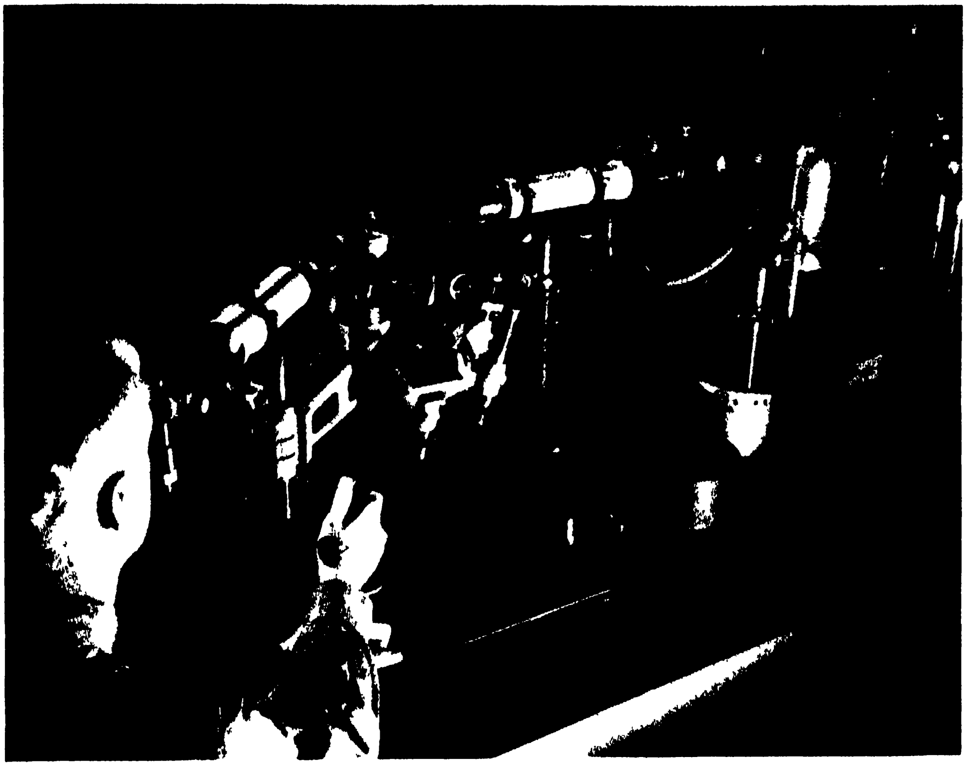
different planes. Focusing thus becomes uncertain and can not be verified by visual observation. With apochromatic objectives, the photographic and visual images are brought into the same plane, and both are equally sharp. Then, since the wave-lengths which are chemically most active are only ¾ of the wave-lengths of those which most affect the eye, the resolving power of an apochromatic objective when used photographically should be greater by a factor of 4:3 than when used visually.

Properties More Significant Than Names

The nomenclature used for optical glasses, such as "soft crowns," "high dispersion crowns," "extra light flints" and many other descriptive terms, mean very little, since it is the definite optical properties of each glass upon which the user must rely in prescribing them for instruments.

The glassmaker attempts to produce optical glasses of uniformly high quality with negligible departures from the standards he has set up. This is important because the lens manufacturer can ill afford to change his grinding and polishing tools to cope with changes in optical properties that may occur from melt to melt. To hold the glass within the narrow limits prescribed, raw materials of high chemical purity must be used, furnace temperatures must be carefully controlled, pots must be chemically and thermically resistant, stirring must not be neglected.

Although the glass technologist is rea-



MEASURING REFRACTIVE INDEX WITH A SPECTROMETER

sonably successful in producing glasses of uniformly high quality to close optical constants, the refractive index of a glass type may vary from pot to pot by several units in the third decimal place. First quality glass, however, should be constant in refractive index within several units in the fourth decimal place.

Purity of Pots

One of the chief efforts of glass research in the United States was to secure pots which would not contaminate the melt. The clays originally available contained, on an average, about 2 per cent of iron oxide, which resulted in an increase in iron content of from 0.02 per cent to 0.04 per cent in the finished glass when a wall of one millimeter thickness was dissolved in the glass.

Through the efforts of Dr. A. V. Bleininger, of the Bureau of Standards, and the cooperation of the U. S. Geological Survey, clays and kaolins relatively free from iron and highly resistant were secured. Pot mixtures have now been developed which approach pure kaolin in composition. Extreme care must be exercised in making and drying out pots to prevent shrinkage cracks. Dr. Bleininger also developed a method for casting pots of the porcelain-kaolin type in which waste bisque of white-ware potteries, relatively free from iron, serves as "grog," the composition of the pot closely approaching kaolin. This pot is exceptionally iron-free and excellent for the dense barium melts which have a tendency to flow through the walls of ordinary pots. The use of a magnetic

separator is also employed as an additional protection against too high a percentage of iron in the clays

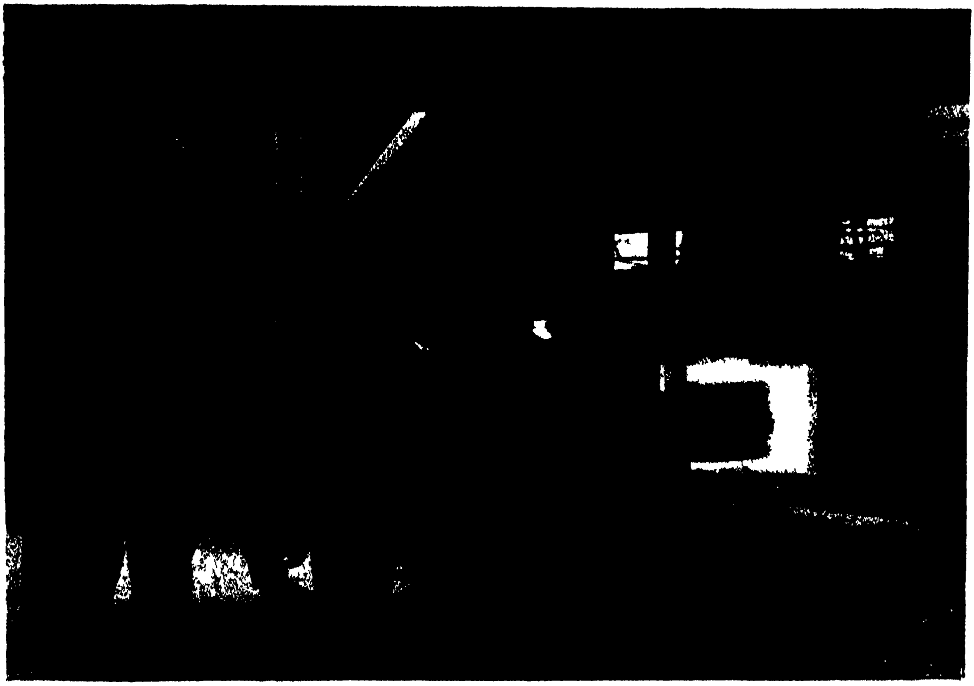
Choice of Furnaces

The tendency in the United States has been toward the uncovered pot due to use of furnaces of the regenerative and recuperative types, in which radiation from the crown of the furnace produces more rapid heating and reduces the melting period Whatever type of furnace is used however, two factors are fundamental to the production of good optical glass—maintenance of a definite temperature over a long period of time and constancy of temperature distribution within the temperature chamber so that the pot is uniformly heated To produce optical glass such careful regulation of furnace conditions is necessary that rarely more than a single pot is melted in each furnace Two-pot furnaces are satisfactory on batches of the same size and composition, but optical glass usually runs to many types and of small quantities as compared to the large quantities of flat glass

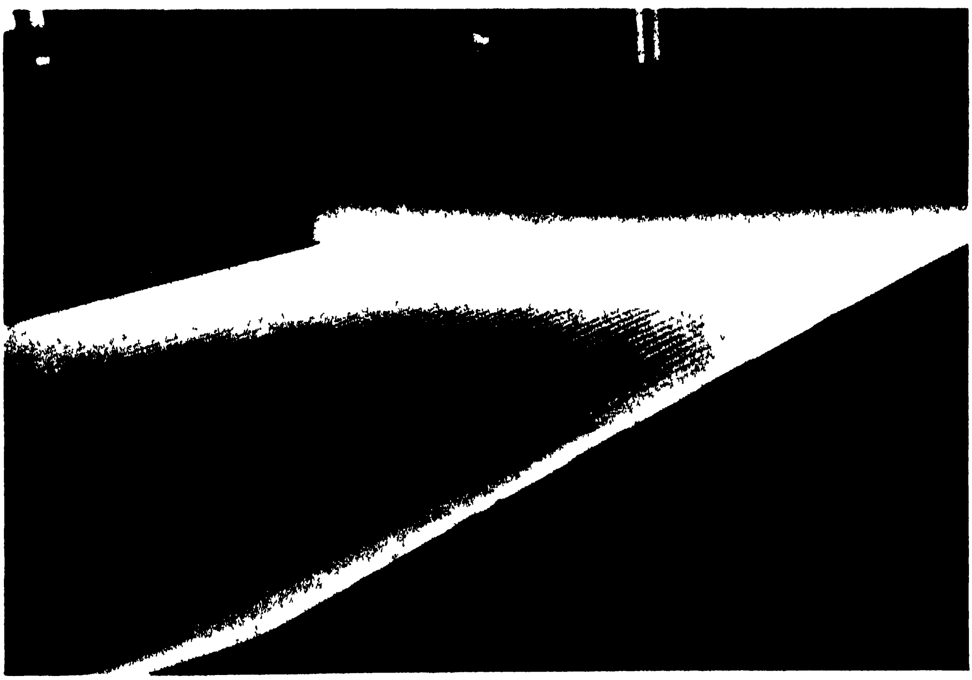
TESTING THE OPTICS OF A NEW RESEARCH MICROSCOPE

The Batch Composition

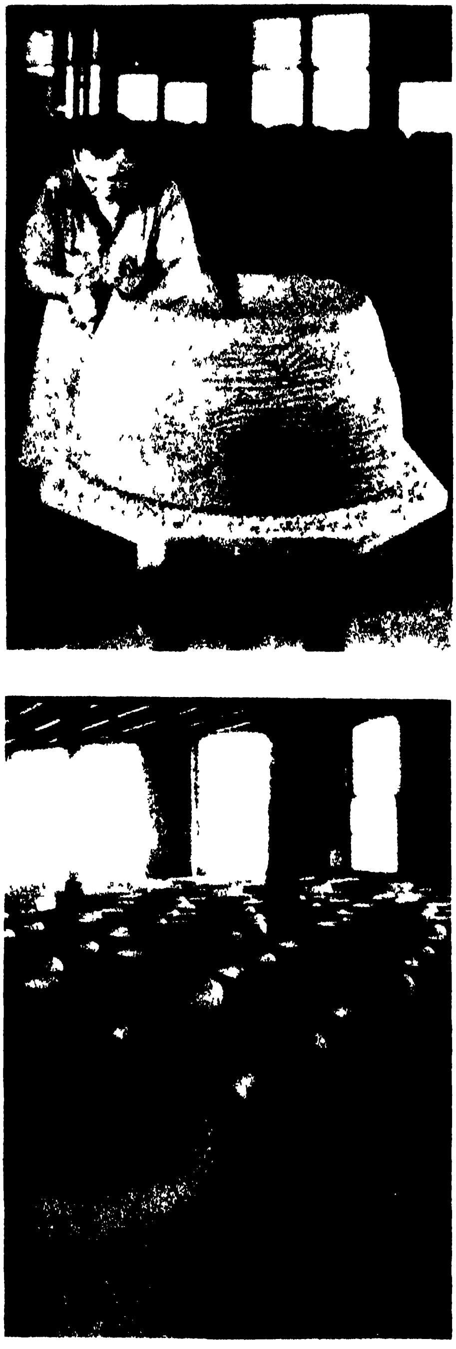
In prescribing the batch composition for a glass of specified refractive index and dispersion, the glassmaker has a number of factors to consider, such as chemical composition and changes of composition that may result from selective volatilization and pot solution In the series of ordinary crowns and flints, silica, alkalies, lime and lead oxide are



TRANSFERRING PREHEATED POT TO A GLASS FURNACE



ROLLING A SHEET OF OPHTHALMIC GLASS PREPARATORY TO ANNEALING



THE MAKING OF POTS
Above BUILDING UP A POT BY HAND *Below* AGEING FINISHED POTS

the essential constituents, but the proportions may not exceed certain limits. If silica above 75 per cent is used, the melt is too viscous; if the alkalies exceed 20 per cent the glass will be hygroscopic and chemically unstable; if there is more than 13 per cent of lime used, crystallization takes place and fusing is incomplete; lead oxide may be used in large quantities, possibly 70 per cent or more, but the danger from crystallization increases.

Boron, barium, zinc and aluminum oxides are the most important constituents of the new glasses. Melts high in barium have a tendency to attack the crucible unless boron and alumina are used, while too much alumina makes the glass so viscous that it is unworkable. Dense barium glasses also require special furnace treatment to secure melts free from bubbles and other defects. The addition of arsenic is often favored because of the increased brilliancy and transparency imparted to the glass.

The batch is charged into the pots as the melting proceeds, and the complete melting and solution of the components is accompanied by an evolution of the volatile components so that the final product is a solution of silicates very nearly free from bubbles. A vigorous stirring of the melt accelerates the solution and melting while reducing the differences in concentration in various parts of the melt.

Stirring for Homogeneity

Stirring was first introduced by P. L. Guinand, an early French glassmaker who used a clay stirring rod operated by hand. The clay thimble is still used but to-day it is fitted to the elbow-end of a water-cooled stirring rod, and mechanical means are employed to impart the desired motions to the rod. Good optical glass can not be produced without stirring. It makes the solution homogeneous and helps to remove or

causes absorption of fine or heavy striae. The rate of diffusion is increased, and the heavy concentrates are prevented from sinking to the bottom.

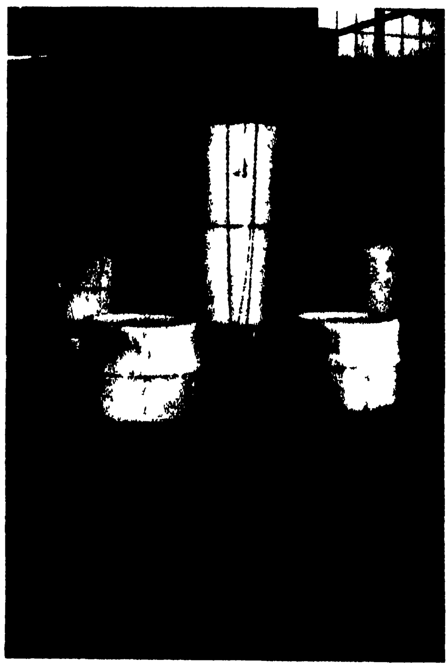
Annealing

Pots of optical glass must be cooled slowly, otherwise crystallites in the surface film may extend downward and form radial spherulites within the mass. When crystallization does occur it ordinarily begins at the top surface and follows to the sides due to the fact that volatilization produces a surface richer in silica, which is the primary phase to crystallize out.

The numerous problems that enter into the process of cooling and fracturing a pot of glass are not thoroughly understood. The more important factors appear to be change of viscosity of the various types with temperature, rates of relaxation of internal stresses at different degrees of temperature, and the temperature distribution within a cooling liquid imposed by the shape and dimensions of the pot.

To regulate the rate of cooling, a hollow, double-walled sheet-iron cylinder, closed at one end, is placed over the pot to retard the cooling rate. The walls are insulated with a diatomaceous earth and the pot is placed in a bed of the same material. A 36-inch pot usually is annealed in three days and a 49-inch pot in five days.

Having cooled to room temperature, the pot is then broken away from the glass, care being taken to preserve all the usable pieces of glass—these rarely amount to more than 25 per cent of the pot, which accounts for some of the expense of the product. In cracking the pot, ordinarily one or more cracks in the glass appear forming an irregular dividing line suggesting where cleavage can be most easily effected. Before leaving the furnace hall, all the glass is examined for striae, stones, color, bubbles, seed, char-



IN PROCESS OF CARING FOR GLASS
Above SALVAGING GLASS FROM A BROKEN POT
Below ANNEALING OPTICAL GLASS UNDER INSULATED DRUMS

acter of fracture, state of annealing, and then sorted to approximate sizes before going to the storage vaults. Pieces at random are selected for measurement of the optical constants and a note of these measurements is marked on the bin and a copy filed for future use. Eventually the glass passes from the vaults to the trimmers, pressers, molders, grinders and polishers. It is again inspected and then returned to the vaults for eventual requisition by optical engineers, who prescribe certain types in the design of optical instruments.

Similarity of the Properties of Optical and Ophthalmic Glass

While a distinction is made in the industry between ophthalmic and optical glass, Bausch and Lomb uses the same pure ingredients for both. Ophthalmic glass is not a cheaper glass, or should not be, but merely a type of optical glass which differs chiefly in the process of annealing, being rolled in sheets on a casting table and sent through a series of annealing ovens. During the process of rolling, the striae, when such exist, are spread out as thin sheets and ribbons parallel with the surface of the plate and hence do not appear after the plate is polished. For many lens elements rolled glass is quite satisfactory because the light passes through approximately normal to whatever mean that may be present, but for such optical parts as prisms, in which the light rays traverse the prisms in different directions, glass free from striae is required and is best obtained by annealing in the pot.

ANALYSIS OF WORLD'S FAIRS' HEARING TESTS

By H. C. MONTGOMERY
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ONE of the popular Bell System attractions at the World's Fair was the hearing test. More than a million people, visitors either to the New York World's Fair or to the Golden Gate International Exposition at San Francisco, have taken advantage of the opportunity to find out how well they hear. Many of them allowed the results of their test to be copied, and have thus made possible the widest survey of hearing that has ever been made. Information available heretofore in these laboratories has been based on studies of a few thousand people at most, while the largest previous survey, that of the United States Public Health Service in 1936 covered only about 9,000. In a sense, the Bell System deals in hearing, and if it is to provide the best service at the lowest possible cost, it is important that it have available reliable data on the hearing characteristics of the American people.

The tests are given in sound-proof rooms arranged to seat seven visitors, each partially screened from the others. Both the tests and the instructions are given through telephone receivers which

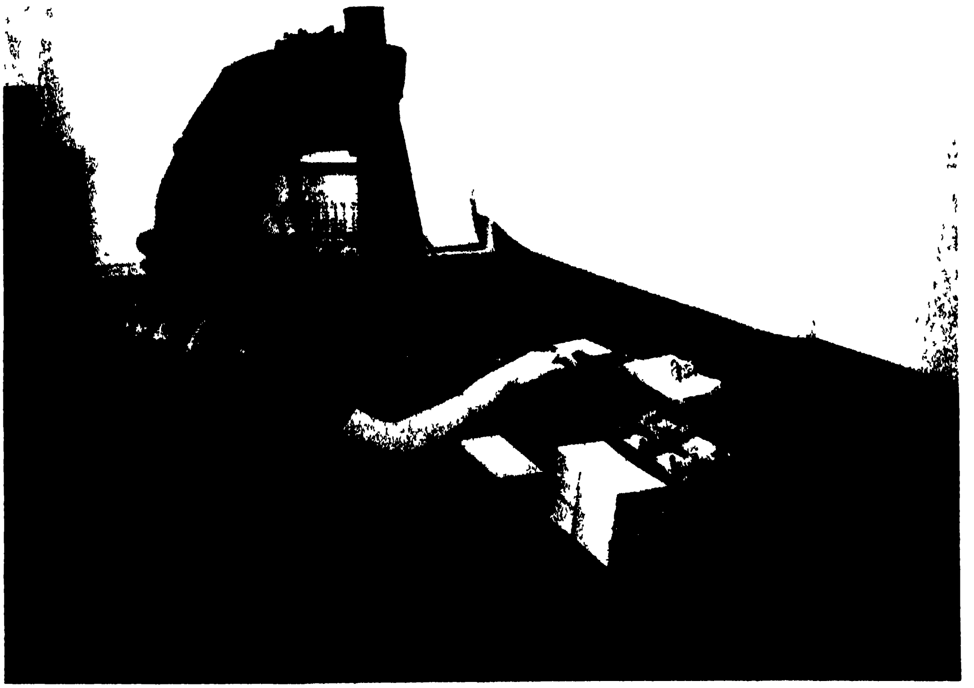

FIG. 1. A RECORDAK PROJECTOR AT BELL TELEPHONE LABORATORIES
PHOTOGRAPHIC FILM OF THE TEST CARDS MADE AT THE FAIRS ARE RUN THROUGH THIS PROJECTOR AND A GIRL TRANSFERS THE INFORMATION ON THEM TO "PUNCH" CARDS

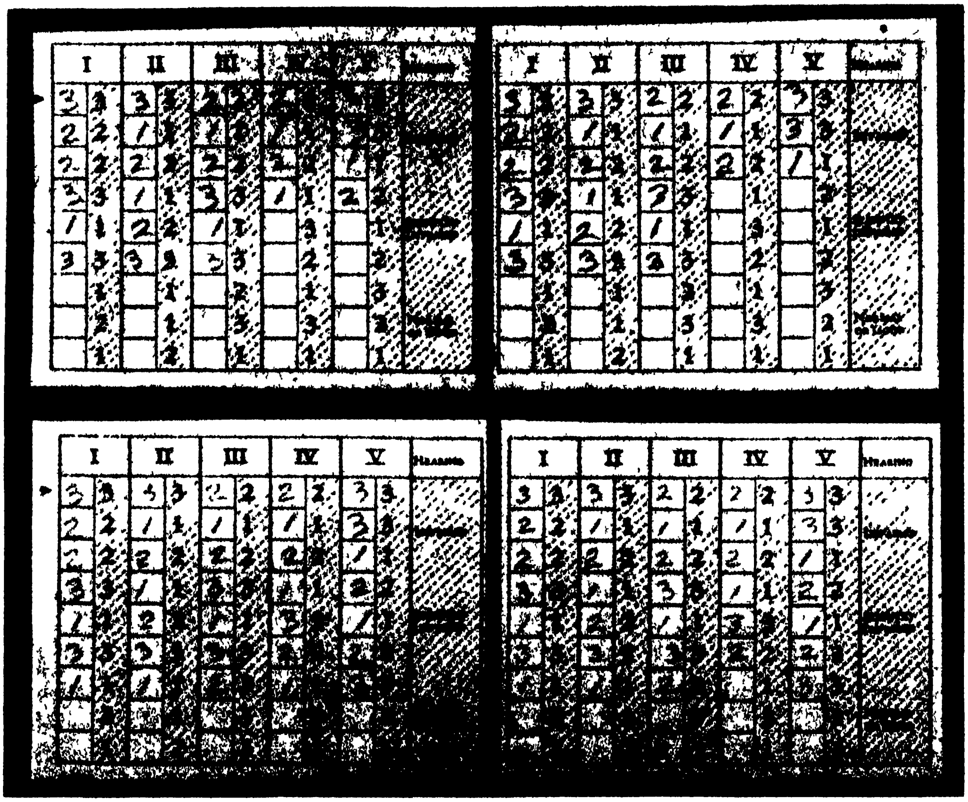

FIG 2 TEST CARDS AS THEY APPEARED AT CHECKING DESKS AT THE FAIRS
AS THEY WOULD BE FILLED OUT BY AVERAGE MEN AND WOMEN IN THE AGE GROUPS 20–29, BELOW, AND 50–59, ABOVE THE CARDS FOR WOMEN ARE AT THE LEFT, AND FOR MEN, AT THE RIGHT THE NUMBERS AT THE LEFT OF EACH COLUMN ARE THOSE WRITTEN BY THE PERSON TAKING THE TEST, WHILE THE DARKER ONES ON THE RIGHT HALF OF EACH COLUMN, WHICH APPEARS WHEN THE CARD IS HELD AGAINST A BRIGHT BACKGROUND, ARE THE CORRECT ONES

the visitors hold to their ear with one hand while they mark the results on a card with the other Two types of tests were given, with separate booths for each In one, the visitor hears spoken words, which are two numbers such as "eight-six," and the numbers heard are written on the card Twelve pairs of numbers are given at successively lower volumes, and then the test is repeated

In the other type of test, the two numbers are replaced by pure musical tones, each tone being sounded from one to three times, and the listeners write down the number of times they hear the tone. Five tests, each consisting of nine sets of tones at successively lower volumes, are given The first is at a moderately low pitch, 440 cycles per second, which corresponds to A above middle C on the piano Each following test is one octave higher in pitch, and thus the hearing is tested at 440, 880, 1,760, 3,520 and 7,040 cycles

At the San Francisco Fair, there were three booths, one arranged for word tests, one for tone tests and one that could be used for either. At New York eight booths were provided for each type of test. The word test gives a good check on one's ability to understand spoken words, while the tone test, by providing

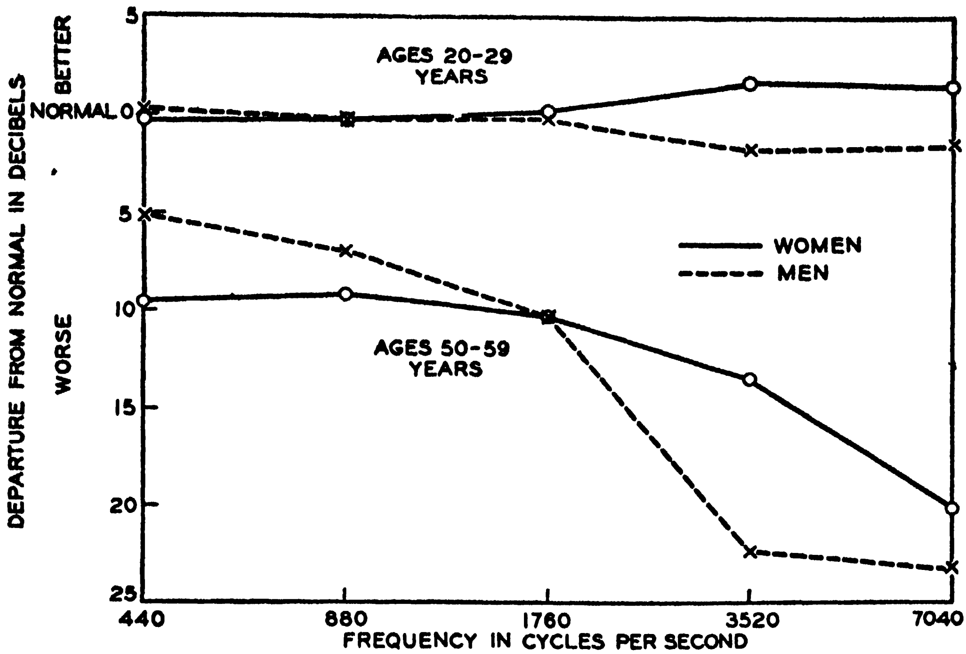

FIG 3. VARIATION IN HEARING LOSS WITH FREQUENCY

FOR MEN AND WOMEN IN THE AGE GROUPS 20–29 AND 50–59 NORMAL HEARING IS TAKEN TO BE THE AVERAGE HEARING OF YOUNG MEN AND WOMEN WHO DO NOT HAVE ANY OBVIOUS HEARING DEFECTS. A PERSON WHO IS COMPLETELY DEAF WOULD HAVE A HEARING LOSS OF 125 DECIBELS.

data at five frequencies over the most important part of the frequency range, is more suitable for study and analysis.

Before a record is made on the test card, the attendant puts a check on it to indicate whether the visitor is male or female, colored or white, and to which of the five age groups—10–19, 20–29, 30–39, 40–49 or 50–59—she judges him to belong The record is then photographed on 16-millimeter film with a Recordak machine At the laboratories the data are transferred to "punch" cards by an operator who views the film in a Recordak projector. The cards are punched to indicate not only the result at each frequency, but the age, sex and color of the subject, and the date and hour of the test. These cards are then run through tabulating machines that analyze and sum up the data.

The results of this survey, in harmony with existing data, indicate a definite falling off in hearing acuity with age This is particularly noticeable at the higher frequencies A rather remarkable fact is that at the low frequencies, the falling off with age is less for men than for women, while at the higher frequencies it is less for women than for men These facts are indicated in Fig 2, in which average hearing loss is plotted against frequency for the age groups 20–29 and 50–59. For a frequency of 880 cycles, which is next to the lowest frequency in the test, the loss for women in the oldest age group is about 3 db greater than for men, while at the highest frequency it is about 7 db less. For the youngest group the differential between men and women nearly disappears at the low frequencies, and is only about 2 or 3 db at the highest

The curves of Fig 3 give the averages only, while it is often important also to know the extent of the deviations from these averages, that is, whether the individuals range widely from the aver-

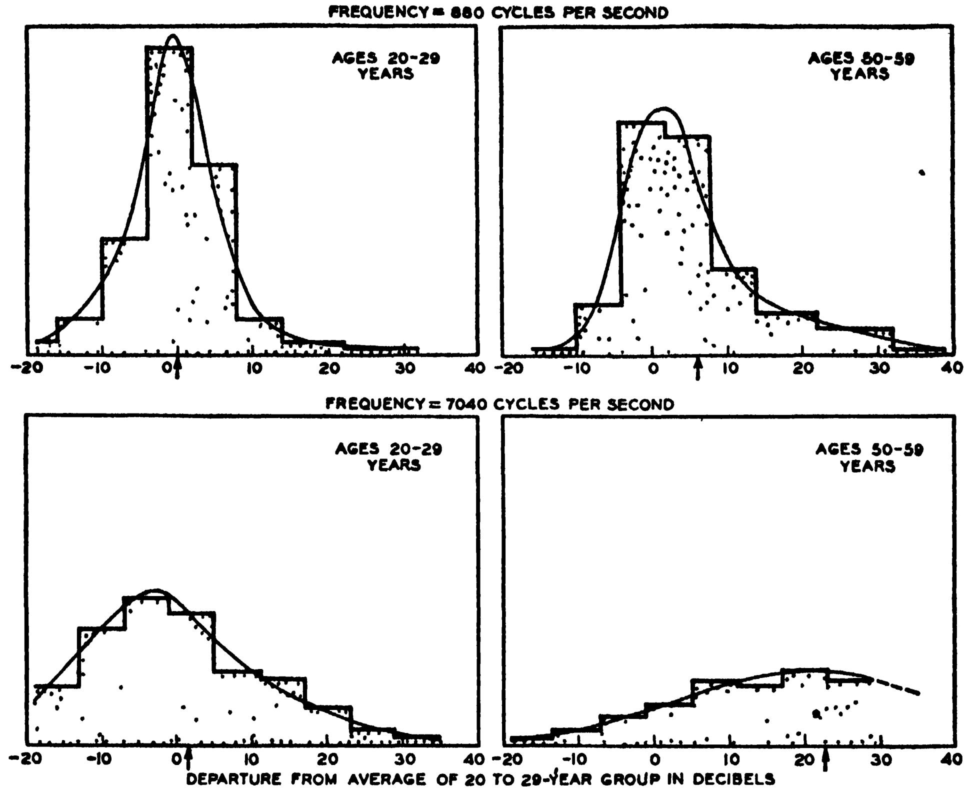

FIG 4 GRAPHS INTERPRETING RESULTS FROM TEST CARDS

age or are closely grouped around it. The distributions of the deviations are indicated by the four curves of Fig 4 These are plotted from the data for men, but use of the data for women would not essentially change their characteristics In each case, the area of the shaded sections represents the total number of tests, and the area under each step represents the number that failed at that step on the test The abscissa scale is the same as the ordinate scale in Fig 3 The small arrows along the abscissa scale indicate the average for that particular age group and frequency The curves actually should extend farther on both sides, but since the range of the test was limited, there is no distribution data available above the highest or below the lowest step, and thus the curves can not be plotted That they extend a considerable distance in some cases, however, is indicated by the positions of the arrow—particularly for the 50–59 age group at 7,040 cycles The arrow is near the right-hand end of the curve because a large number of cases lie beyond the distribution shown The light curves are drawn to indicate the general form of the distribution curve From these curves it will be noticed that for young ears and low frequencies, the tests are grouped fairly closely around the average—very few falling more than 15 db away. For older persons or higher frequencies, however, the distribution spreads

Not all the cards have been tabulated as yet, but as additional tests are examined, they are found to fall in line with those already tabulated, and so there is little likelihood of any major change in trend being encountered as the tabulation proceeds. The interpretation of the losses at various frequencies is rather

difficult except for specialists, since the evaluation of the effect on one's ability to hear in any particular band of frequencies is a function of many factors. It has been found, however, that one's ability to understand speech can be determined from the average of his hearing losses at 440, 880 and 1,760 cycles as compared to good young ears If this average is 25 db, there may be some difficulty in hearing in auditoriums and churches, while if it is 45 db, there may be difficulty in hearing in direct conversation Only if it is as much as 65 db will there ordinarily be much difficulty in hearing over the telephone

By use of these figures, the tests indicate that about one out of twenty-five persons have difficulty in hearing in auditoriums; one in 125 will have some difficulty in direct conversation, and one in 400, over the telephone Two out of five men between 50 and 59 will have a loss of at least 25 db at 3,520 cycles, while only one in 5 women—half as many—will have as great a loss at this frequency It was found, also, that about 1 in 25 of the group from 10 to 19 had a loss of at least 25 db at 7,040 cycles This figure is significant because otologists have found that young people with a hearing loss of this amount will often tend to become progressively worse in later years, but that if remedial measures are taken, the hearing impairment may be largely checked.

It should be kept in mind that these proportions apply to the records obtained at the fairs They can not be applied to other groups or to the population at large without considering differences in age distribution, economic status, nationality, and other similar factors. For example, the proportion of people over 50 in the population is considerably greater than among the fair visitors, and it is estimated that this fact would nearly double the percentage having a loss of 25 db at the lower frequencies It is also necessary to consider to what extent the hearing records obtained represented a fair sample of the visitors to the fair A study of these problems of interpretation is now in progress

During part of the summer, visitors at each fair were asked to indicate whether they lived in the vicinity or not, so that information would be available to determine sectional differences in hearing acuity Studies of these answers, however, do not reveal any significant difference between New York and San Francisco The time of day at which each test is taken is marked on the card by the attendant, thus permitting a comparison of the results for different periods of the day No consistent difference has been found, however, even between early morning and late afternoon. There is thus no indication of any effect of fatigue on hearing.

ORGANISM, SOCIETY AND SCIENCE

I. ORGANISM

By Dr. R. W. GERARD
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THIS essay, in two parts, is an attempt to evaluate the deeper significance of science for the society in which it is embedded, by approaching the problem through the essentially biological conception of organism Now, more than ever in the past, it is urgent that scientists give thought to the human consequences which flow from their activities.

UNIT AND WHOLE

The concept of organism, as a semi-independent unit system composed of lesser units in interrelation with one another, need not be developed here It applies to solar systems, snow crystals, atomic nuclei, and football teams no less than to micrococci, maple trees and men. Animate organisms constitute a subclass in this broader category, sharing the general attributes and adding their particular ones; and it is these I wish especially to consider. Unfortunately, no differential terms exist for the entire class and for those subclasses of organisms which are living individuals or for those which are not Perhaps such words as "animorg" and "inanimorg" for these respective groups will prove useful additions, but for the present I shall use "organism" in the more restricted sense of an individual *living* organism

That the demarcation of living from non-living is fuzzy and sometimes arbitrary, I am well aware; yet over most of the range the differences are clear enough (though sometimes practically undefinable), and it would serve no present purpose to scrutinize the transition zone The extension of the attributes we find for organisms to societies of them—to epiorganisms, as I propose to call these—is, on the contrary, a central theme of this essay, and the justification for this will presently be examined.

An organism, whether uni- or multicellular, possesses three major attributes: it is in open dynamic equilibrium; it performs specific synthesis, and it manifests adaptive amplification The first is concerned with the maintenance of the living machinery, with the steady flow of substance and especially of energy through the system, which is necessary to preserve or perpetually renew its highly improbable architecture, facing, as it does, the forces of disintegration and the second law of thermodynamics. Its peculiar substances, especially the enzymes and related catalytic molecules, and its peculiar organization, especially the electrically charged colloids and membranes, must be retained or renewed, howsoever that uninterrupted process of change, which is living, swirls about them The physico-chemical flame is commonly called metabolism, the fuel being supplied by digestion and absorption and the oxygen by respiration, the burned wastes being removed by excretion, and with a moving fluid contributing to the transport of substances about the larger individuals Whether by elaborate organ systems or by relatively undifferentiated protoplasm in the single cell, these various functions are discharged and the organism is enabled to persist as itself, a particular system in approximate dynamic equilibrium.

Superimposed upon this rapid and relatively stable process is a slow directional drift of the whole equilibrium, for growth punctuated by reproduction is as

universal as maintenance Increase in mass (growth) or number (reproduction) or complexity (differentiation) requires the manufacture, out of protean and simple crudes, of the particular substances (and patterns) present in and partly unique to the individual This specific synthesis is, of course, related tc the constructive aspect of metabolism but can not simply be equated with it The mechanisms for building the living machine—by autocatalytic enzymes and gene duplication, by chromosome apportionment and cell division—vary but little from the simple to the highly elaborate organism Only the devices for the reproduction of multicellular individuals are introduced and elaborated at successive levels of evolutionary change

The behavior of organisms, the running of the living machine, shows the greatest variation from one kind to another, though still basically alike in all Some environmental change, acting as a trigger, elicits a response by the organism which releases more, often incomparably more, energy than was contributed by the stimulus. Further, this amplified energy release is directed in such a manner as to remove or counteract the disturbance and to reestablish equilibrium within the organism and to adapt it to its surroundings Adaptive amplification thus depends on irritability, on some sort of spread of excitation within the organism, and on a final response by appropriate parts Evolution has led to "advance" most clearly in this attribute of organisms; for the "higher" organisms differ most from the "lower" in that, because of specialized receptor elements, they are more sensitive to more types of stimuli, and, because of specialized effector and conductor elements, they perform more elaborate and coordinated actions more rapidly, and, because of specialized portions of a coordinating nervous system, they manifest greater latitude in the kind and interval of response to given situations, to the extent that there is a strong appearance of choice and initiation of action.

Metabolism and growth may be as adequate in the single primitive cell, even in the cell removed from a multicellular unit, as in the highly elaborate primate, but behavior is not. Adaptive amplification is associated with the organism as a whole, and so is especially a function of its total organization. And so we shall return to living things as organized systems and to some consideration of organism in its broader connotation May I use the term "org" to denote this inclusive sense of organism?

An org has persistence in time and boundaries in space, both of which may be short or ill-defined. During its recognizable integral existence, however, or during some differential segment of it, the org endures in approximate equilibrium. Within it there exist interactions between parts and between part and whole which also endure as constants. True, the mechanisms of coordination may themselves be dynamic equilibria, as we shall see, yet in intergrating the parts into the whole, the lesser orgs into the greater one, they are essentially static forces independent of time's arrow. The point has sometimes been made that when some event is most clearly related to an antecedent one the latter is spoken of as its cause, when to a subsequent one, it is called its purpose. This might be extended by the statement that when two or more events are clearly related contemporaneously they constitute an org

This raises the vital problem of the character and direction of the determination or control or correlation or causation or force, as you will, acting between part and whole As to direction and degree, the possibilities are limited; either the constituent unit or the org may determine the other partly, completely, or not at all. If neither determines the

other at all, there is clearly no org but rather chaos If each determines the other completely, there results a closed isolated system, only the entire universe can qualify as such. If determination is complete in one direction, say the org is fully controlled by its units, then the system can be externally influenced only at the unit level, that from which control is directed; and, in effect, the reciprocal direction of control is non-existent. But this is tantamount to denying organization, for the essence of an org is that the units in it act differently from solitary ones by virtue of their incorporation in the system As Whitehead has said, "an electron blindly runs, but within the body it blindly runs as conditioned by the whole plan of the body " Within the atom it runs in circles, outside it in straight lines It follows, then, that determination between the org and its units is always reciprocal and always partial and that the system can be modified by the environment acting upon it at either level But enormous quantitative variation is possible within this frame, as is clear from a study of organisms.

The living cell is, or course, an org, and one of a high order, for its constituent units are orgs, *e g* collodial micellae, and their units are orgs, *e g*, protein or lipoid molecules, and so on for a regression through several levels It may also be an organism, one of the unicellular protozoa or protophyta, or it may be a unit in an org of still higher order, a multicellular organism Indeed, the cell which is a unit in an organism may be a more elaborate org than one which is itself an organism—compare a nerve cell from the mammalian cerebrum with a micrococcus—but perhaps our present needs will be served by an analysis of the relation between a cell and an organism, as a clear example of the more general relation between a unit and its org.

At once terms are indeed to connote differences between orgs of the same order, terms analogous to "higher" or "lower" as applied to organisms. I shall use "integrated" for this distinguishing property and refer to orgs as highly or poorly integrated, or as differing in integration This will refer primarily to the final step, so that an org of order N + 1 may be composed of highly integrated units of order N and yet be poorly integrated. The sponge, for example, is such a case, it is a poorly integrated organism containing highly elaborated cells It is perhaps obvious now, and will become more so, that as the integration of an org increases the determination of the unit by the whole also increases relative to that of the whole by the unit That is, the balance of control shifts from the cell to the organism as we pass from the lower to the higher (and more recently evolved) forms of living individuals

Mechanical Correlation

Since organic evolution presents us with a rich spectrum of organisms for study, the intraorg determinants can be particularly well analyzed in this field. Perhaps simplest are the mechanical and geometric relations. An active muscle cell changes its shape anisotropically, the muscle shortens and thickens, exerts a tension through tendon on bone, and this, usually acting as a lever, causes gross movements Conversely, the development of muscle, composed as it is of thousands of cells oriented as long spindles or cylinders parallel to each other and along the tension axis, depends in considerable part on the existence of a stress in the tissue When a muscle's tendon is freed and the stress removed its cells degenerate. Bone cells similarly accumulate in the spongy interiors of bones so as to deposit their calcareous spicules along lines of stretch and compression. A median section of the femur is a perfect engineer's stress-strain dia-

gram drawn in lines of calcium salts And the stress determines the cell behavior, for when a broken bone sets at some abnormal angle, the old spicules are destroyed and new ones are laid down in accord with good engineering practise. Further, from one animal to another closely related one the leg bones do not simply follow in their linear dimensions the size or weight of the animal. A doubling in linear dimensions would increase volume and weight eight times, or as the cube But since the resistance of a bone to crushing decreases with its length and increases with its cross section, to support an increase in weight the leg bone must become relatively more chunky, increasing in diameter more than in length And so it does—compare the legs of the heavy percheron and the light thoroughbred, or of the gazelle and the elk

Or consider the hydrostatic and dynamic consequences of blood pressure and flow The entire circulation of the blood is based on the mechanics of that good pump, the heart By the flow in the capillaries and by the filtration of fluids through their walls due to blood pressure, the tissue cells are kept freshly supplied with nutriment A maintained excessive blood pressure may cause multiplication and hardening of the cells in the vessel walls, arteriosclerosis, but excessive pressures can not normally persist any considerable time, for the stretch of certain receptors in arterial walls initiates reflexes which slow the heart, dilate the vessels, and reduce the pressure This last example involves, of course, another coordinating mechanism, the nervous system, as well as the mechanical one—but such interaction is the rule A like case is the throbbing pain from an inflamed tooth, the vessels of which swell with each pulse as it compresses the nerves between bony walls

In less integrated organisms such mechanical factors as blood pressure and muscle tension, even gravity, decrease or vanish but others become more prominent The shapes of cells are partly determined by the pattern in which they are packed together—polygons, spheres, cuboids, pyramids, cylinders, spindles, plates, etc, are formed in harmony with the configuration of the tissue In some very lowly multicellulars, as slime moulds or a number of the algae, this packing effect of juxtaposition is almost the only factor relating the individual cells with one another

Within the single cell, alone or in a group, the dominating mechanical factor is surface tension Not only does this contribute importantly to shape and to movement but also to cell size and division Since the compressive force exerted increases as the radius of curvature decreases, too small a droplet may be, so to speak, squeezed to death and too large a one may fall apart

It is important to note two points illustrated by the foregoing examples First, as we pass from less to more integrated organisms the variety and magnitude of the mechanisms operating between the individual and its cells increase, especially in the direction from org to unit Second, though the same general control exists in orgs of different order it may operate through quite different machinery Surface tension within the cell and gravity or blood pressure within the many-celled organism are all mechanical forces; but it would be fatal to extrapolate from integration within the cell to that within the large organism These generalizations apply in even greater degree to other means of control, especially that of transmission

Transportation Correlation

Chemical factors of coordination, or more generally transportative ones—since heat, for example, as well as particular substances, may move from place to place

—are of great importance. In the simplest cell, a unit or an organism, molecules move through the protoplasm by their own kinetic energy and diffuse from a region of greater to one of lesser concentration En route they may be blocked or retarded by membrane barriers which are completely or partially impermeable to them, or they may enter into chemical reaction and be lost.

Since the amount of oxygen, for example, required by a cell increases in proportion to the volume of its protoplasm, or the cube of its radius, while the surface through which this gas must enter increases only as the square of its radius, transport by diffusion soon limits the possible size that a cell may attain. Further, the time required for diffusion varies not with the distance to be traversed but with its square. It is not surprising, then, that as cells reach large sizes—some simple algal cells are several millimeters in diameter—diffusion becomes inadequate The protoplasm becomes spread as a thin layer within the outer membrane and the core of the mass is composed of a "sap" of simple salt water which is kept stirring around by still unknown means How much more important must transportation become in multicellular organisms!

Part of a single cell, severed from the rest so that the cell nucleus is not included, dies, but as little as one thirtieth of the cytoplasm, containing the nucleus, may live and regenerate the lost portion The nucleus is thus essential to the maintenance of other cell parts, whether the cell is itself an organism, as in the case of an adult protozoan or the egg of a metazoan, or is part of an organism, as in the case of a nerve cell This latter is particularly striking, for the fine fibre of a nerve cell may stretch a meter or more from the nucleus-containing cell body, and it receives its independent blood supply, yet it dies when the tenuous connection is cut There is evidence here that substances (enzymes) elaborated in the nucleus spread to the far ends of the cell with the aid of peristalsis-like movements in the protoplasm.

Such chemical factors of coordination within the cell are extended and elaborated in the many-celled organism. A mere clump of initially like cells must acquire the rudiments of organization at the multicellular level as a result of their spatial arrangement and the diffusion situation, for the inner ones are partially cut off from the free exchange of materials with the outside world by being buried under the outer ones Their rate of activity is consequently less than that of the more favorably placed units, and this quantitative differential is an org determiner This aspect will be further elaborated shortly as the basis of the highly important gradients in orgs.

In more integrated organisms transportation is improved and new chemical coordinators are introduced. The sponge drives a current of sea water through its open structure by the beat of flagellated cells The plant moves water up its woody tubes by osmotic and other action of its roots and by evaporation from its leaves The flat worm churns a mixture of partially digested food and water about its widely arborized gastro-vascular cavity. The crab has a true circulating body fluid pumped to the cells through tubes by a crude heart but seeping back through the loosely knit tissues In the vertebrates we encounter a fully developed vascular system and efficient heart which sends the blood systematically about the entire body. The time required for fresh fluid to move through the body and be renewed about each cell is progressively diminished despite the ever greater distances; in man, arterial blood is steadily rushing through the capillaries, and perhaps half a minute completes the whole body circuit

Also, with improving integration, the composition of the circulating medium is

ever more elaborate and, even more important, more constant; so that most cells are, in effect, no longer exposed to the external environment at all but to a made-to-order internal environment Their growth, state of action, even the direction in which they differentiate, are extensively controlled by this chemical milieu. A change in the salt proportions of blood can speed or stop the heart, send arm and leg muscles into spasms or paralyze them completely, act on the brain to given delirium or coma, and the like But alterations of such magnitude are normally prevented by the action of liver, kidney, and other organs A slight change in carbon dioxide content can cause violent or suspended respirations, and a rise or fall in blood pressure, and this gas also helps to modulate the supply of blood to any tissue or organ by dilating or constricting the blood vessels serving it.

Here, in fact, is a beautiful example of interaction between org and units Only by maintaining a constant head of pressure in the whole system can the blood supplied to any one cell be regulated to its needs. As a cell or cell group becomes active, it requires more food and oxygen; but with increased activity it produces more carbon dioxide, which opens the vessels to it and so establishes the greater supply. But if too widespread local dilation occurs, blood pressure falls and all cells suffer Other mechanisms, neural in character, protect against this under normal conditions, and under extreme stress or deprivation, when not all cells can longer be adequately supplied, the mechanisms even break down in an orderly fashion, for the heart and brain are properly nourished to the bitter end, long after gut and muscle, etc, have been deprived of their sustenance.

Not only are the more universal constituents of protoplasm held in constant or properly modulated concentration in the *milieu interieur*, but a whole new set of chemicals, the hormones, has been added in the higher organisms. These substances are transported in the moving medium and control the action of few or many kinds of cells other than those which form them Growth substances pass from the tip of a shoot and make the cells along the stem elongate; acid in the upper part of the gut releases into the blood a hormone which excites pancreatic secretion, from the thyroid comes an internal secretion which makes a tadpole's tail shrivel and its legs sprout, from the hypophysis is released one substance which matures the sex glands and another which sets off the thyroid Again it is clear that, as an organism becomes more integrated and its parts more interdependent, more substances of more powerful or specific action are transported more rapidly and under better direction. Further, the machinery of transport may be widely different at the level of the cell and at that of the metazoan organism.

Transmission Correlation

A third type of integrating mechanism in organisms is transmission, and the machinery for achieving it shows the widest range of all organismic devices Transmission depends on the passing on of energy, or better of an excitation which sets off successive local sources of energy, rather than on a transport of molecules Waves in water, light and other radiations, electric currents, produce effects at a distance from their origin by transmission A spark burning along a fuse is similarly transmitted—at each region the heat generated by burning ignites the next stretch, but no molecules move along the wick

The nerve impulse, like the spark in a fuse, propagates excitation Electric currents rather than heat pass between an active and a not yet active nerve element, the current acts on the latter

to produce chemical and membrane changes; the resting portion thus becomes active and helps initiate the same sequence beyond it. Nerve cells and their cable-like extensions are an advanced evolutionary achievement, making transmission far more efficient, but in essence the same process occurs in all protoplasm

When a sperm fertilizes a sea-urchin egg, a wave of change radiates out from the point of penetration over the entire cell membrane. This can be followed visually, since a fine pellicle is raised as the wave travels and is seen to require nearly half a minute to travel a tenth of a millimeter to the far pole of the droplet When the tip of one "finger" of a sponge is pricked, a "message" slowly creeps along the animal causing the pores to close over a distance of centimeter or less The transmission is faster than in the egg, perhaps a centimeter a minute but, since it dies out as it travels, more distant portions of the animal are very little affected. This org is poorly integrated indeed

The jelly-fish possesses primitive but unquestioned nerve cells scattered in its mass which, making casual contact with each other's processes, form a loose net When any part of the animal is stimulated, excitation travels in all directions over it and the whole organism responds as a unit Conduction in this organism is greatly speeded up along the special nerve highways to as much as ten centimeters a second, and it can travel for unlimited distances—500 miles round and round a ring cut from the periphery of the umbrella Further, the energy of the stimulus required to elicit a response of the animal is greatly reduced, for specially sensitive receptor cells, the touch organs, have appeared, and the response is more rapid, powerful, and adaptive, for specially constructed effector cells, the muscles, are also added

In the earthworm, nerve cells are clumped together in ganglia, the beginning of a central nervous system, and connect with each other in formal and regular patterns Transmission may be at a rate of a few meters a second, is unlimited, and is no longer randomly directed The anatomical connections determine set behavior patterns, or reflexes, and particular muscles are excited from receptors at particular locations. Further elaboration, in the vertebrates, results in a complex continuous central nervous system with peripheral nerves making well-defined connections to receptors and effectors Nerve impulses sweep along at rates over 100 meters a second and the courses they take, while limited by the anatomical possibilities, are determined to a considerable extent by the functional states of several alternate pathways This element of modifiability progressively increases to the human nervous system with its relatively enormous cerebrum

Important and progressive changes occur in the central nervous system, once it is established, as the organism becomes more highly integrated The jelly-fish has no centralized nervous system, the flat worm and more evolved phyla do have one The former has a central body axis with respect to which its parts are arranged in a radial symmetry, the latter are bilaterally symmetrical about a central plane along which lies the nervous system Further, the whole animal, and its neuraxis, is polarized parallel to this plane so that there exists a more active head end which takes the initiative in behavior and a more passive tail end which follows after The elongation of the body, the anterior-posterior differential, and the central nervous system arise and develop together

The more stimulated cell or portion of the organism becomes more active. How this comes about we need not inquire here, but the generalization is very widely true and can be observed under all sorts

of test conditions. In a roughly radial animal a temporarily more active sector would tend to lead and become the front end during movement—as frequently a larger arm of a starfish drags the clumsy animal in the direction that it points But the front end gets most of the bumps, is differentially more stimulated, becomes ever more active and dominant, and so more steadily the leading end So, presumably, have the actual gradients of activity—measured by quantitative differences in metabolic rate, sensitivity to poisons, and speed of movement, along the anterior-posterior axis—come into being in all bilateral animals

Now such quantitative gradients are not, *per se*, dependent on any nervous system, for they are present and important in plants and axiate animals which have no nerves. But since they are intimately bound up with excitation, it is not surprising that the nervous system and sense organs are especially concerned with them The main receptors develop in the head end, those distance receptors (as the ones serving smell, hearing and vision) which give information of the environment before it is encountered, exclusively so, and the nervous system follows after The receptors are at the apex of the pyramid and come to dominate the entire organism

This effect is seen most immediately in the central nervous system. Not only does the anterior, or cephalic, end of the nerve stem dominate the remainder, but the entire organ comes to be located ever more forward until the separate ganglia become clumped together well in front of the body segments they still innervate Far more important, this segmental nervous system, each part still functioning primarily for the control of its own body segment, is supplemented with suprasegmental structures which deal with the whole organism These new structures arise from the particular portions of the nervous system which receive nerve impulses from the distance receptors, the cerebellum from those of balance and hearing, the cerebrum from those of smell and vision.

These cortices clearly represent a development in response to the organismic need for adequate and integrated response to the ever more numerous and differentiated sensations delivered by improving receptors Information about the outer world arrives in greater profusion, with finer discrimination, with more alternatives of import, and hence there is need for an improved machinery for selecting, evaluating and integrating it and for deciding on the single total response or individual behavior The cerebral cortex increases in absolute and relative size as animals ascend the scale, and the response of the whole organism, as a single unit, to its environment is more elaborate, variable, intelligent and unified In short, the cerebrum, almost uniquely, is the center of integration of adaptive amplification or behavior.[1]

A further word is needed concerning gradients in relation to coordination within the organism These intensity gradients represent a regular progressive change in some quantity with a similar progression in distance along the body axis. But particular kinds of cells and organs are also located in regular sequence along this axis. Hence the probability arises that the structures determine the intensity, or vice versa It does

[1] Transmission, and a part of the nervous system, the visceral or autonomic system, comes also to supply important intraorganismic controls comparable to the other mechanisms earlier outlined The internal reflexes controlling blood pressure have been referred to, similar elaborate sets, always in pairs the members of which oppose each other and so insure fine control, regulate the action of each organ system—respiratory, digestive, excretory, etc,—in terms of itself and the others Body temperature depends, for example, on nervous control of skin blood vessels, sweating, hair erection, muscle relaxation, breathing rate, water distribution, etc This also finds a social counterpart.

not seem probable that organs would chance to be ordered from head to tail in such sequence that each had a lower metabolic rate than the one before it, but it seems even less likely that the metabolic rates of certain cells should determine which organ they will become Yet something close to the latter is true—morphology is often determined by metabolic rate, not the absolute rate so much as the rate relative to that of other regions in the whole organism.

The evidence for this conclusion is clearest in experiments on regeneration of flat worms. When such an animal is transected somewhere near the middle of its longitudinal axis, the cells at the cut end of the anterior piece regenerate into tail structures, those at the cut on the posterior piece form into a new head Since it is entirely a matter of chance whether any particular group of cells near the section was incorporated into anterior or posterior half, but it is fully determined by their position whether they become head or tail, it follows that the course of their differentiation is controlled by their relation to the other cells in the piece Actually it is known that cells at the high end of a gradient will develop toward "headness," including sensory and brain structures, those at the low end, toward "tailness," including digestive elements.[2]

Here then is a completely static determiner, the gradient (itself depending on rates of change which are steady equilibria) which molds units in structure and function by virtue of their location on a quantitative scale in the whole org. This was seen in detail in the nervous system, which actually "migrated" toward the head end and which, being kept near the top of an activity gradient by steady excitation from sense organs, developed the dominant and characteristically organismic cerebral cortex.

Cell-Organism Relations

By means of such mechanisms, then, a group of cell units becomes ever more of an organism, less of a mere collection. A more integrated organism, compared to a less integrated one, has more kinds of cells which are largely more differentiated and therefore interdependent. Each cell alone has lost much of its original heritage of totipotentiality for doing and becoming—cells sacrificed their immortality, self-sufficiency, many of them even parenthood, in becoming part of a metozoan—in exchange for some one expertness of function and one elaborate structure The problems to be solved by the organism are distributed among specialized units which are individually skilled, each for its own task, and which depend completely on mutual cooperation for their own survival and that of their organism

This progressive interdependence is seen especially clearly in the matter of survival after injury, and in the repair or regeneration of lost parts The sponge can regenerate from one or a few cells; the flat worm, from a moderately sized piece of the body, say an eighth; the crayfish dies following any major insult to its body, but can still regenerate an eye or leg; the mammal can not replace any lost organ, but certain tissues—skin, connective tissue and blood, some glands—can still grow and repair after injury The sea-urchin egg, still undifferentiated and an org of very poor integration, can regenerate when only 5 per cent. is left; the adult vertebrate (less so the echino-

[2] The picture sketched is extremely simplified, for not one gradient but three or four general ones operate along the coordinates of symmetry, and these are further supplemented by more local "fields" diminishing circumferentially with distance from a dominant center The morphogenesis of any cell is, then, the resultant of these many, sometimes partially conflicting, gradient relationships rather than of any single one. It is necessary to introduce these complexities now to show later the parallel with the individual when subjected to multiple social influences.

derm), a well-integrated org, is promptly killed by any extensive amputation or even wound.

The organismic mechanisms for bringing about this cooperation are, like the units, progressively elaborated, specialized, multiplied and, particularly, strengthened. It is customary to note conflicts in nature, the struggle for survival and ruthless competition among living beings. What is often overlooked is that cooperation, mutual aid, individual sacrifice for the larger group, are perhaps even more wide-spread and are the fundamental biological "virtues." They are virtues in a strictly objective sense and on the same criterion of fitness and adaptation, for they have a high survival value. At every level—within the single cell, the colony, the simple or elaborate multicellular individual —differentiation of parts and their cooperative integration into a whole gives the possessor real advantages over his more homogeneous competitors

A further word on self-sacrifice for the common good will help emphasize this aspect of living units When the lobster is caught by its claw, it sheds the appendage, escapes, and eventually grows another. But the claw dies. The organism, by a sort of voluntary act, here sacrifices a part, the latter has little control over events. When, however, a mammal is subjected to cold, the blood vessels in the skin and subcutaneous tissues constrict, thereby minimizing loss of body heat through the surface, but inevitably allowing the anaemic tissues to cool still faster. The constricted vessels, as well as the cells they serve, may thus die—an ear or toe offered up to preserve the whole. Even in this case, it could be maintained that the organism enforces this action, since the vessels cramp down to their own destruction under whipping of nerve impulses from the autonomic nervous system. Similarly, with the paralysis and anaemia of the gut which accompanies strenuous muscular exertion—in an emergency requiring maximal effort, running for one's life—adrenaline is liberated by nerve action and this shunts blood and extra food reserves to the muscles. Even in the case of a leucocyte which, unlike its prototype the free-living amoeba, moves into rather than from a chemically injurious portion of its environment and is commonly killed while combatting infecting bacteria, there is really no question of voluntary altruism of the unit dying for the organism; for physical and chemical forces pull the cell about by its mechanical tropisms

This raises the question of freedom and purpose It follows from the already considered existence of reciprocal controls between the org and its units that environmental changes can act through the org to alter action of the unit, as well as the opposite This maneuvering of units through the org, always so as to preserve the whole, carries the connotations of volition and of purpose—alike in animate and inanimate systems, in conscious and non-conscious ones We do not know the nature of the mechanism which arranges bone cells along stress lines, or that which "chooses" one or another neuron to set off selective muscle action; or even that which directs a thrown ball into a parabolic trajectory, though in this simpler case we have named and quantified it But certainly the mechanisms exist and the org acts upon its units, often regardless of their existence as discrete units

Is there, then, any true freedom of action of unit or org not fully determined by org or unit and the outer world? I have neither the competence nor time to splash in this long running argument But, whether or not a residue of free choice adheres to an org (and is multiplied in amount as the org increases in order; not by blind amplification of the

indeterminism of the unit but more nearly by an exactly opposite relation), its action is overwhelmingly determined at any moment by conditions external to it and those built by its history into its organization and so equally outside of its immediate control In fact, "freedom" does not correctly imply the irresponsibility and absence of control so often attached to it. A "free" system, on the contrary, is one acting under the undisputed control of a single determiner or a group of allied ones; that is, running without conflict A free falling body, a free sailing boat, a free swinging magnet, illustrate the point "Free" orgs—including cells in the organism and organisms in the epiorganism—are ones responding with relatively little conflict to preponderantly allied forces, all tending to produce this kind rather than alternate kinds of activity As Whitehead has said, "For effective freedom nature must be orderly No condition is so servile as that of him who is subject to a capricious and incalculable tyrant "

Much could be added on the breakdown of org relationships in organisms, but a brief paragraph must conclude this portion of the essay Malfunction of all types is recognized, and much disease is the result of partial breakdown of the integrating mechanisms The usual anatomical or functional lesions—general edema from kidney disease, fainting from poor heart action, irritability from gastric ulcer and ulcer from a type of irritability—are familiar enough But one form of org disintegration, the splitting from the whole of fairly independent portions, deserves comment

The gradient along a flat-worm is low at the tail end and rather peters out when the animal is sufficiently long The subordination of posterior by more anterior regions similarly weakens, and when this control is feeble enough the tail piece is essentially in the same org relation that it is when the front portions of the animal have been amputated. It then develops into a head and, finally, a complete small new organism still attached tandem fashion to the "parent" individual. Such a zooid, as it is called, eventually becomes torn away from the front portion and both lead normal existences; but before this happy solution occurs much conflict results from the independent behaviors of the tandem partners Similar loss of unitary org control is involved as one factor in the formation of two-headed and other types of twinned monstrosities, in special embryo-forming tumors, or teratomas, and in the more familiar forms of cancer

MUSICAL INHERITANCE

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THE whole problem of mental inheritance is in the air, both in the sense that it is current and in the sense that it is relatively intangible The struggle is best illustrated in the current approaches to the problem of inheritance of intelligence. In this the geneticist has not gotten far from base, but much has been learned in regard to the nature of the issues involved In the field of music the geneticist has approached the subject experimentally without understanding the musical life; and the musician has approached the matter practically without being a competent experimenter The psychologist has certainly not done his duty in clarifying the issues The most pressing need at the present time is for such clarification. This can not be the work of one man or one generation, but must be achieved through cooperation of both sides in order to clear the way for valid experimentation.

In order to indicate the character of the problem we are now facing, I shall first venture to state some fundamental assumptions upon which probably all competent investigators agree and, second, venture a little way in the direction of identifying concepts of musical life which can be dealt with experimentally

ESSENTIAL PREMISES

The mechanism of heredity lies in a single germ cell carrying the character-determining chromosomes which consist of organized chains of genes In the character and organization of these genes in the fertilized cell we find the complete "blue print" for the future individual in so far as it is to be determined by heredity. In the twenty-four pairs of chromosomes in the fertilized human germ cell we find the long and diversified heritage of each parent represented through the union of the sperm and the ovum The selection and the organization of the genes in these chromosomes adequately represent what the future individual can be

This genetic constitution is modified by the cytoplasm, the supporting part of the cell which is its first environment, and further by the entire embryonic environment Any changes that take place after the launching of this cell, whether before or after birth, are regarded as environmental In the embryonic life, this germinating cell develops by processes of cell division and specialization into the complete human organism ready to function more or less immediately after birth This heritage has fabulous resources in the form of possible facilities for future development As nature was prolific in the storing and transmission of countless hereditary characters in the genetic constitution, so the equipment of the child at birth is astonishingly prolific in the provision it makes for diversified development of the individual Development from this stage on must, therefore, of necessity take place through a process of selection and specialization in which certain characters are given right of way and many are subordinated or inhibited by conflicting interests, but the great mass remain relatively latent or dormant We may assume that superior musical talent is determined in large part by superior musical heredity, and that inferior musical talent or lack of talent may be determined in large part by a correspondingly defective heredity

The science of heredity in the strictest sense focuses upon the study of the identification and organization of the genes in relation to the determination of characters which shall appear in the genetic constitution and determine future structures and functions of the individual When the geneticist deals with specific anatomical structures, this relationship is traceable with comparative ease, but when he comes to deal with more or less complicated physiological or mental functions, the tracing of this relationship becomes rather baffling on account of the complexity of the final product.

Turning then to the issues involved in the interpretation of musical inheritance, we must face certain theoretical assumptions. One of them is that a scientific study of musical heredity can not be pursued on the assumption that mind and body are two distinct entities, each inherited independently. Nor can we hold the old doctrine of psychophysical parallelism. All human genetics proceeds on the assumption that the human individual is one psychophysical organism Our musical experience, observation and measurement will therefore represent views from the mental side; our organic studies may be views of the same things from the physical side.

Furthermore, musicality is not one specific human trait but an infinite hierarchy of traits running through the entire gamut of the psychophysical musical organism. To make any progress whatever, the scientist must make the supreme sacrifice of attempting to deal only with specific isolable factors apparently small and remote in themselves The situation is analogous to that of purely physical features It is generally admitted that the structure of the physical organism is heritable But when we show that the color of the eyes of the fruitfly is heritable and that this inheritance takes place in a very complicated way, as has been adequately shown, we have simply identified parts of the structure and function of the genes in one specific feature in the vastly complex physical organism, however fundamental and characteristic this particular feature may be. This analogy applies in principle to the genetic study of the musical life. The crux of the difficulty lies in the identification of heritable factors.

Again we must remember that the musical mind is first of all a normal mind, a normal psychophysical organism ready to begin to function immediately after birth What we shall look for then in a psychophysical organism is the imminence of certain resources especially favorable or especially unfavorable to the normal functioning of the musical mind. We may assume that an average capacity present in the genetic constitution may be adequate for musical purposes but that exceptionally gifted persons require these traits in a correspondingly exceptional degree and that exceptionally unmusical individuals lack essential elements. The most wonderful thing is that a person can come into the world with a musical constitution at all, but the problem of heredity centers around individual differences, and these are more easily approachable than the total function. As in genetic studies of the inheritance of color-blindness it has been possible to identify types, so in musical hearing we may look forward to the identification of types of defect and types of superiority deviating markedly from the normal.

Common observation and reasoning convince us without question that musicality is inherited in some mysterious way and this follows also from general considerations of current theories of biological inheritance. But when it comes to the scientific determination of laws of such inheritance, we face high barriers. Biological laws of inheritance must be established in terms of the genes; a specific biological structure or function

must be related to gene organization. Let us call this measurement of the first order. Such measurements are most readily applied to anatomical structure and physiological function in the neuromuscular organism. This is notably clear in the anatomy and physiology of the ear and its connections. It is equally applicable to the anatomy and physiology of the vocal organs—the bellows, the vibrators and the resonators for voice It is conceivable, for example, that the length, the mass, the mode of attachment, and the general position and shape of the vocal cords and the mounting of the voice box are heritable characters traceable to genes and referable to musicality as the physical organs for voice

We can also find relationships to the endocrines, which are in large part the determinants of musical emotionality. Electro-physiology is now giving great promise for the identification of functions in the ear, the brain and its central connections and is establishing interrelationships Many of the laws of heredity established by measurements of this order probably refer to fundamental biological principles of inheritance in the psychophysical organism as a whole. By a physiological analysis of the sensory, motor and central factors which operate most significantly in music, the systematist can set up a respectable body of biological facts in regard to musical inheritance which are antecedently probable in terms of the functions of genes and result in the structure and function of the musical organism

Since the medium of music is sound, we shall look first for an exceptionally responsive or unresponsive ear, including not only the physical ear but the central organs in the nervous system through which it functions This is basic for two reasons: first, because it determines what stimulation from the world of sound shall enter into the experience of the musical individual to a high degree, and second, because the purely physiological receptivity or organic response to sound acts upon and modifies the state of well-being or ill-being according as the auditory impression is beneficent or noxious in so far as its acts upon our circulation, metabolism, temperature and other organic processes. Such well-being or ill-being is, of course, in part the foundation for the feeling of musical pleasures and pains.

If we would gain a true and comprehensive insight into the nature and extent of role of environment in musical life, we must start with some established facts or reasonable assumptions of what is "given" for environment to act upon. The heritage is the capital fund which the environment invests or squanders. Only by knowing the hereditary contributions can we appraise the environmental contributions. In the study of the fruitfly, for example, the revelations of factors which must be regarded as environmental are quite as significant and essential as the revelations about the original organization of genes. The determination of the limits of heredity is the best means for revealing the functions and possibilities of environment. The music geneticist will therefore learn fully as much about environmental influences as he will about hereditary influences in studying heredity

Psychophysical Measurements

The music geneticist can approach many significant aspects of the subject through psychophysical experiments for which we now have fairly standardized procedures. For the present purpose, we may call this measurement of the second order as compared with the anatomical and physiological measurements. It proceeds out of, and is a complement to, the anatomical and physiological foundations and probably represents the most fundamental approach from the psychological and musical points of view. These mea-

surements deal primarily with sensitivity and discrimination on the sensory side and the corresponding processes on the motor side Among them we may recognize two levels the simple or elemental, in which a specific mental process is related to a relatively specific organic basis, and the complex, which relates to cooperative functions of the elemental capacities Of the former we have four, namely, the sense of pitch, the sense of loudness, the sense of time and the sense of timbre—each of which is correlated with a specific attribute of the sound wave, which is the musical medium. We have basic measurements of the hearing of rhythm, consonance, volume and sonance—all of which represent relatively complex patterns. Each of these complex functions has a unitary character. Rhythm, for example, is not merely time plus intensity, it possesses a unitary character Because of the difficulty of dealing with the complex patterns, precedence should be given to the four elemental or basic capacities. Excellence in these capacities contributes toward ear-mindedness, of which the auditory image is the most specific characteristic, but at the present time we have no adequate objective method for the measuring of auditory imagery.

On the motor side we have corresponding measurements of speed and accuracy in the motor control of each of these factors represented in the sound wave, namely, frequency, amplitude, duration and form.

The term elemental should be used with caution because we never encounter a purely elemental state or process. Even in the very simplest form they are merely more or less specific phases of the mental organism, and at any level at which they are observable they probably involve environmental accretions. It is the old story: we never experience pure sensation but meaningful perception Yet under the most careful experimental control the identification of such specific functions may be reasonably reliable and have considerable validity.

Adequate measurements of the sense of timbre are new and therefore have not been employed extensively up to date. But the sense of pitch, the sense of time and the sense of loudness, together with the sense of rhythm and immediate tonal memory, have been used extensively.

The significance of such measurements depends upon the rigidity of the scientific technique and the selection of subjects for experiment Reliable measurements have been made on a variety of groups and for different purposes more or less related to the problem of inheritance Studies have been made upon musically precocious children to determine to what degree they were gifted in each of these capacities All the available blood relatives of six of the foremost musical families in America and a number of such families in European countries have been investigated. These capacities have been measured in selected virtuosi in various fields of music The measurements have been used for the determination of qualifications for musical organizations and for the analysis of admissions to music schools Simplified forms of the measurements have been made upon very young children in musical families Numerous cases of failure in musical education have been investigated and often explained on the basis of presence or absence of these basic capacities. Surveys have been made on groups representing highly privileged or under-privileged children in the matter of musical facilities. Some of these measures are now a part of the standard tests and measures administered in the public schools so that comparisons can be made with blood relatives, and data are becoming cumulative for scientific comparison of successive generations Numerous racial studies have been made on a large scale comparing these capacities, for example, in dif-

ferent degrees of race mixture—as in the transition from pure blacks through mulattoes to whites in a large Negro community, or the comparison of racial groups in Hawaii, the school children in different European countries, the comparison of Indians with whites, and the comparison of distinctive races and primitive peoples in different parts of the world.

From this large array of facts certain findings seem to be significant, taking these measurements as a group First, the sense of pitch, the sense of loudness and the sense of time reveal no distinctly significant differences in racial groups, in culture-levels, or at age-levels, when adequately measured. In many cases this holds also for the sense of rhythm and tonal memory. This is probably indicative of the fact that the basic capacities for hearing in individuals now living and capable of being tested adequately are physiologically at the same level This conclusion is in harmony with the observation that these capacities which function in music, function also in the vast varieties of orientation through sound at all levels of man now living It is also analogous to what has been found in vision. Second, it develops that in each and every one of the groups studied there are enormous individual differences in each of these capacities and that the extent and distribution of these differences do not differ significantly from what we find in the public-school children of the United States. Third, where comparisons of capacity and achievement have been made reliably, it has been found that those who have achieved distinction in music have these capacities in a significantly corresponding degree, but much larger numbers of those possessing superior capacity who have not been discovered as musical either by themselves or in their environment are revealed This fact rules out many of the statistical studies of heredity in terms of musical achievement. Fourth, these capacities represent relatively independent factors in hearing Fifth, marked superiority or inferiority in these capacities is of predictive value for musical achievement and guidance in education

On the motor side but little progress has been made Principally because the measurements are laborious, significant elements have not been identified, and moderate motor capacities in speed and action are adequate for most musical achievements Daily observations reveal that children may be slow and accurate, slow and erratic, fast and accurate, or fast and erratic in various degrees and combinations It would, however, be of musical significance to discover to what extent and in what manner these traits are inherited from generation to generation

In view of these discoveries, it is evident that there is some material available for technically rigid genetic interpretation in terms of currently recognized principles of inheritance All the records on the six foremost musical families of America are available in the confidential files of the Carnegie Institution at Cold Spring Harbor Highly reliable measurements on all the students in the Eastman School of Music for the last fifteen years are available Various public schools have vast cumulative data, and elaborate collections are being worked upon in the Winderen Laboratory at Oslo But with the exception of the Carnegie Institution and the Oslo collections, adequate measurements of whole families are absent

What is needed now is a thoroughly reliable series of measurements on entire musical families and the interpretation of these by a thoroughly competent geneticist in terms of established biological principles of inheritance. It is especially important that both parties shall be competent to take into account the numerous

lessons which we have learned from the extensive efforts that have been made in the attempt to measure the inheritance of any mental trait, such as human intelligence. In the human situation we can not breed successive generations rapidly as in flies or mice for experimental purposes. We must, therefore, economize time and effort by taking the most readily available material. For this purpose I have suggested three possible methods ("Psychology of Music," McGraw-Hill, 1938). The first is that we start with the highest 10 per cent and the lowest 10 per cent. in an adequate sampling of fifth-grade children in a school system and work back by making the same measurements on the available blood relatives of these two groups. In effective organization much time can be saved by making group measurements in a cooperating community, such as a city ward A second procedure would be to secure an adequate sampling of musicians and measure forward and backward to cover three generations in which the matings of musical and unmusical parents could be traced A third procedure would be a systematic collection of measurements on school children for a generation or more giving special attention to the showing of blood relatives We can not, however, stress too strongly the importance of having these measurements made throughout by an experimenter thoroughly competent in this field and the equally thorough biological treatment of data by scientists thoroughly competent in that specific field If a biologist wants to start the ball rolling from his point of view, the records in the Carnegie Institution furnish a fair and reliable sampling

In proposing this conservative approach through psycho-physical measurements, I do not wish to belittle the insight, common knowledge and theories of inheritance which have been obtained by observation and statistics in terms of musicality as a whole—as in biography, autobiography and letters of great musicians or in the study of musical families But we are confronted with the fact that these deal largely with unanalyzed situations so completely covered by factors of environment and training as to make them useless for strictly scientific purposes. Nor would I belittle the significance of general traits, such as musical intelligence, creative imagination and the artistic temperament, or facilities for specific skills, such as sight reading and the memorizing of repertoires We know a great deal about these and unquestionably have the right to assume that they have an hereditary basis But scientific studies in heredity may be more properly approached through the simpler and more elementary capacities.

For scientific purposes, we can not, of course, mix basic measurements and current ratings of musical achievement. There have been numerous approaches to this subject from the musical achievement point of view, and these have furnished many suggestive leads and probably point to unquestioned facts about the inheritance of musical talent. But the science of genetics rightly rests upon and demands the isolation of specific factors which can be measured, and for that purpose the musical geneticist must, for the present, sacrifice many otherwise interesting approaches from the point of view of rated achievement and be willing to await the laying of foundations of rigidly conducted measurements which can be described, interpreted and verified

THE "CHAIR" FOR INSECTS?

By Dr. ROBERT CUSHMAN MURPHY
AMERICAN MUSEUM OF NATURAL HISTORY

A Pitfall in Eden

On a warm and peaceful evening I recently gathered new evidence of man's unique predilection for slaughter for its own sake. I was sitting alone on a flagged terrace that was sheltered on two sides by glass and on a third by the clapboards of an ancient and stately Connecticut home The fourth side opened on the bland night air and on velvet shadows of box and great beech and tulip trees, while a familiar garden close, bowling green and fountain showed dimly under the sky reflection, with a backdrop of inky woodland beyond

The floor and table lamps had not been turned on, but a light suspended above my singularly comfortable chair made the enclosure glow pleasantly against the dark, and illumined a thousand specks that were beetles, moths, leafhoppers, lace-winged flies and other small companions resting on the ceiling and painted woodwork. It was August, the Indians' "moon of insects," a fact confirmed by the rattle of tree-crickets and a mingled orchestration from hedge and garden that combined with the faint stir of leaves and other sounds too elemental to be discriminated without an effort to create the ambiance of a summer night

In the midst of such contentment, however, there was one false note At intervals of seconds a slight crackling, quite unlike the so-called "voice" of any insect, rent the air with an incisiveness out of all proportion to its volume At first vague and puzzling, it presently centered my attention on the lamp itself, which became white and dazzling when the eye was lifted to its level

The light proved to be fulfilling the purpose of a lure and deathtrap. Cylindrical in shape, its gleam in all directions passed between the bars of an electrified metal grid. Flying insects, even if as minute and filmy as mayflies, closed a circuit upon coming into contact with the bars. The crackling noise was simultaneous with a tiny burst, or sometimes a prolonged flutter, of blue flame, after which a scorched being dropped soundlessly into the projecting catch-pan at the base of the lamp

I went indoors, hunted up a cardboard box in which to store the cupful of dead or maimed insects for future reference, and then turned off the switch of the light, ending its hazard for the moment

The Voice of the Salesman

It took but a few days to become versed in the many cheerful possibilities of electrocuting insects, of which I had hitherto had no realization After perusing the manufacturers' unprejudiced assurances, it seemed almost obvious that live-wire control was at the point of conferring inestimable benefits upon mankind in the way of increased comfort—not to mention the boon to agriculture

"What! No mosquitoes? Exactly!," read one illustrated account. "This device, scientifically designed, combining attractiveness with effectiveness, utilizes illumination to entice insects to destruction It annihilates flying pests instantly, providing absolute insect-free contentment to outdoor-loving people. Summer evenings offer the most wholesome opportunities Our lamps are for the control of pestiferous and harmful

insects that fly in the dark They eliminate the destructive worms bred by night-prowling pests, by killing the adult egg-layers "

"It is all very well," sang the author of another disinterested paean, "to speak of the enchantment of gardens lighted at night, of the peace to be found at twilight in a comfortable chair on lawn or terrace, of supper out under the stars, but how can all this be enjoyed when mosquitoes and gnats and moths buzz and sting and fly? The gardener and his guests can but flee to the screened house, leaving the fragrant garden to the insects At least that is what they have had to do for years past. But today one can purchase a simple electrical device that, though harmless to humans, is death to bugs, and enjoy the garden at nightfall in comfort, while mosquitoes and bugs literally 'get the chair ' "

Not stopping at products that combine the ordinary domestic purpose of a lamp with a lethal function, the makers also advertised, among their many types covering a wide price-range, a mercury bulb trap for use "wherever bright illumination is not desired; the light source emits those parts of the spectrum that are attractive to insects " This can apparently be relied upon to get them anywhere, during daylight hours as well as in darkness It may be hooked up at the far end of the garden, or out in the forest, for that matter If the mountain will not come to Mahomet, Mahomet must go to the mountain Still another lamp is recommended for situations where insects "are not prevalent in great abundance " It is important, it seems, to catch the stragglers and thus be on the safe side High praise, in fact, is accorded a "portable bug-killer," which should be in all travelers' luggage and which is credited with a virtue of "luring every flying insect in a room at night."

THE TESTIMONY OF THE CONDEMNED

By the time I came to the point of analyzing the catch from the first electric live-broiler of my acquaintance, I had gathered several additional cargoes of insect corpses, similarly finished off during the same summer season. It began to appear that these admirable lamps had earned for themselves a wide vogue

Let us now sort and name the spoils, concealing nothing, adding nothing, and remembering, of course, that the samples represent but one general locality in Connecticut and only the month of August And, lest any reader should rightly question my personal competence to identify and comment upon a varied assortment from the largest class of living organisms on earth, let me say that I have been at pains to submit all the specimens to professional entomologists whose reputations and authority are recognized by men of science everywhere.

The vast majority of insects have no common names, and to list the victims from three distinct catches by their respective Latin generic and specific names would result, from the layman's point of view, in wholly impractical jargon. Let us, rather, refer to them with the least possible degree of technicality, which will inevitably be bad enough. And let us follow the summaries of their kinds and numbers with notes upon their relation to nature and man, and, when called for, a further qualification based upon the somewhat contingent and artificial terms "beneficial," "neutral" and "injurious."

Plecoptera

Stone flies, or salmon flies One example of these water breeding insects, the larvae of which live in swift streams and furnish food for trout. Beneficial

Homoptera

Frog-hoppers, or spittle-bugs, the larvae of which make the curious masses of foamy froth

in the grass. Four examples of one species. Food, chiefly weeds Beneficial or neutral

Leaf hoppers. Sixty two examples of seven or more species. Various members of this family are under certain circumstances to be regarded as pests, but the bulk of them are normal elements in the life of the woods, thickets and pastures. Even lawns have an abundance of leaf hoppers, to which no horticulturist need pay attention. Neutral, or at most only slightly injurious

Neuroptera

Lace-winged flies, aphis-lions or golden eyes (*Chrysopa*) About 40 examples, representing one or more species of an exquisitely beautiful four-winged insect which one entomologist has described as "fit only to go on an Easter card, so pale and esthetic are her light green wings" The food habits are almost uniquely important to man, for in both the adult and larval stages the golden-eyes eat nothing but plant lice and scale insects Neither the gardener nor the farmer has a better friend

Lepidoptera

Sphinx moths One small example, too burnt for identification. Although minus its wings, it was discovered to be alive at least twenty-four hours after electrocution The feeding habits of the Sphingids are various, but the adults are flower-pollinators and the group as a whole is probably more beneficent than harmful.

Arctiid moth (adult of one of the woolly bear caterpillars). One example of a species that lives chiefly on such weeds as plantain Beneficial

Noctuid moths One example each of three species, the first a harmless feeder on such flower heads as wild asters, the second occasionally destructive to beans and other leguminous plants, the third a true pest because its caterpillar is one of the cut-worms Neutral and injurious.

Geometrid moths One example of a small leaf feeder, the adult of an inch worm Generally regarded as injurious, although most of the large number of species are normal inhabitants of trees and lesser plants, attaining economic importance only in peak years of their population cycles Because they furnish food to many predacious animals, including other insects and birds, they also form a large part of the "pasture" of nature

Pyralid moths Twenty one examples of several species, mostly of the genus *Crambus* This large family includes sundry pests, such as the introduced European corn borer, which, however, was not found in our catch The native species become troublesome chiefly when, because of the absence of some natural control, they break out in unduly large swarms. The caterpillars of *Crambus* are the familiar sod webworms, which cause neither farmers nor gardeners any serious concern. Furthermore, they constitute a source of food for ground feeding birds such as meadowlarks, particularly for the nestlings Neutral

Tortricid moths Fourteen examples of various species and sub-families The introduced codling moth or apple worm does not appear among the victims, which feed, respectively, on grapes, birches, sassafras, pitcher plants, goldenrod, certain garden shrubs and other vegetation All or most of the catch must be regarded, from man's point of view, as no worse than neutral.

Gelechiid moth One example of the genus *Recurvaria*, a minor pest on evergreens and ornamental shrubs Injurious

Diptera

Chironomid midges Five examples representing one or more kinds of these harmless insects which compose the swarms that dance in air, the mass as a whole remaining in one position. Neutral

Ceratopogonid flies Two examples of a biting midge. Since these are annoying, we may call them injurious.

Crane flies One example of the genus *Anisopus*, which breeds and feeds in wet and decaying vegetation Neutral

Gall midges Twenty examples representing several forms of the family Cecidomyiidae, a group that includes the notoriously destructive Hessian fly This objectionable species, however, does not appear in the catch, which is made up of native gall makers on various weeds and other plants and of one or more kinds that fulfil the desirable function of devouring plant-lice Injurious and beneficial

Dolichopid flies One long headed fly of the genus *Neurigona*, which captures and eats midges and other small soft bodied insects and their relatives Neutral or beneficial

Blow flies Two examples of green bottles or Sarcophagids, which are well known disposers of carrion and therefore beneficial They are chiefly diurnal insects and their presence in the light trap may be accidental

Tachinid flies Seven of these economically important insects, not in sufficiently good condition to be identified as to species They are parasitic upon caterpillars, grasshoppers and other insects, depositing the eggs or larvae upon the skin or within the body of the host. Beneficial

Anthomyiid flies Eleven examples of the

leaf-miners, genus *Pegomya*, one example of which is the generally injurious corn-maggot fly. Of the other species one sometimes infests beets, another ivy, but most of them attack burdock and other weeds. One additional closely related fly among the victims is a scavenger on decaying vegetation. Injurious and neutral.

Sciarid flies. Two or three examples of a fungus-gnat, which breeds in toadstools and other fungi. Neutral

Coleoptera

Ground beetles (Carabids). Five examples representing five different species All are man's co workers, because these beetles feed upon soft bodied plant eaters, of which caterpillars comprise the bulk Beneficial

Hydrophilid beetles. One example of a land-living relative of the true water scavengers It feeds upon fly larvae in dung and decaying vegetation. Neutral

Rove beetles. Three different small representatives of this family, the Staphylinids. They live in decaying organic matter, preying in part on other insects. Beneficial or neutral

Click beetles Two examples of an Elaterid, the larvae of this particular form being root-borers on woody plants. Possibly injurious

Scarab beetles Two examples representing two species of the genus *Aphodius*. These are dung-beetles of generally harmless habits Neutral.

Chrysomelid beetles Three examples representing three species of small leaf-eaters. Perhaps to be classed as injurious, though nothing to worry about.

Hymenoptera

Ichneumon wasps and other parasitic insects of this group Seventeen examples of several kinds, not identified as to particular species All of them are of great importance because their larval stages feed upon and destroy caterpillars, wood borers and other insects which man also has to combat. Beneficial.

Ants Five examples of two or more species of winged ants. They are to be regarded as beneficial because of their value in reworking the soil, which in some districts exceeds that of earthworms

Who Flies to the Light?

The roll of victims, in conjunction with the explanatory remarks demanded by simple justice, tells its own story. There is probably not one serious enemy of man in the entire sample. "Pestiferous insects"—by any other criterion than that of outmoded squeamishness—are conspicuously scarce. Especially noteworthy is the absence of a single mosquito, although our little morgue contains the bodies of a number of non-biting Chironomid midges that are often mistaken for mosquitos

"Most bugs, moths and insects," writes one sponsor of the electric method who plays fast and loose with zoological terms as well as with the truth, "are attracted by light, so with any one of these electrocutors night life (the garden variety) becomes much more enjoyable Even to the music lover the song of Mrs Anopheles is never welcome To prove to this mosquito that she is an undesirable companion, there is one efficient way—electrocute her."

What this writer means to say would be interesting if we could rely upon it, but it is up to the lamp manufacturers first to show us evidence of mosquitoes decoyed against their live wires. It so happens that while mosquitoes have been experimentally attracted by electrically controlled vibrations that reproduce the hum or muscial note of their whirring wings, and while they respond to some extent to warm surfaces, the readiness with which they react to various types of illumination, including the "New Jersey light trap," is still a moot point Furthermore, Wats and Bilderbeck, experimenting in India, report that "8,000 other insects, mostly beneficial," were caught during ten hours' use of an "Entoray" machine along with only 19 examples of anopheline mosquitoes! Neither is it a fact, as stated by the writer of the foregoing quoted paragraph, that "most insects" exhibit the reaction called "positive phototaxis," although an unfortunately large proportion of *useful* kinds appear to do so.

The moth that flutters into the flame

of the candle is both an ethnic tradition and an everyday observation, and the story is usually cited to point a moral. The strange response is not due, however, to an idle curiosity that leads the creature to "play with fire," nor is the infatuation determined by its own volition. On the contrary, such suicidal behavior is purely automatic. The mechanism of phototaxis, which may be either negative or positive, is highly complicated, differing greatly among various groups of animals and even among closely related insects Under the influence of a distant source of light, such as the moon, a photopositive moth can maintain a straight course. When, however, the light is close at hand, the angle of rays striking certain cells in the retinas of its eyes is constantly changing The rays are converted into energy that affects its muscle-tone asymmetrically, and its movements follow what is called a logarithmic spiral which leads it ineluctably toward the source.

Now it is common knowledge among economic entomologists, who have long made use of various types of light-traps, that the bulk of the undeniable pests are not drawn to such lures The Japanese beetle, to choose an example that everybody knows, remains quiet and beyond temptation after nightfall More perverse still seems the fact that in certain large families of nocturnal insects the greater number of species are photopositive, but many of those particularly inimical to man's interest are not! That this is somewhat damaging to claims for the annihilation of "destructive worms," as put forth by the electrocutioners, will doubtless not alter their sales tactics.

In the opposite balance of the scale we have seen evidence that the light-susceptible insects, which succumb to the treacherous lamps, include many such indispensable forms as devourers of plant-lice, parasites of plant-eaters and pollinators of blossoms. Furthermore, those aquatic insects that at one period or another of their life histories furnish the natural food of fish are highly photopositive, and incalculable numbers of them have already perished on electric grids.

Ignorance plus unscrupulous advertising, coupled with the prevalence of many night-flying insects (sometimes including mosquitoes) along waterways, has led to a ready sale of the diabolical lamps to owners of cottages on the banks. One of the foremost advantages of homes so situated lies in the opportunity for fresh-water fishing It is ironic, to say the least, that contraptions on the porches of countless such residences throughout the vacation season are nightly luring to destruction a host of caddis-flies, fish-flies, stone-flies, Dobson-flies and mayflies, the immature stages of which furnish an irreplaceable prey for trout and other fish. Such insects do no harm whatsoever The Dobson-fly, for instance, is the parent of the odd, water-living hellgrammite, crawler, hell-devil or conniption-bug, which spends two or three years under stones in the stream bed before emerging as a flying adult, and which, as every country boy and ardent angler knows, makes an irresistible bait for bass

Insects as Friends and Foes

A distinguished American entomologist once made the modest statement, "In the large economy of nature insects are beneficial " Most authorities would put the case more emphatically, because it is certain that higher forms of life, man included, could not survive on this planet without them It is unnecessary to recount the manifold reasons, but, for example, our textiles depend upon insects —silk because an insect is the manufacturer, cotton and linen because of direct fertilization of the plants, wool because

insect-pollinated clover is necessary for the rearing of sheep Even though insects inflict damage upon orchards, there would be no orchards without insects to crosspollinate the blossoms. From the standpoint of such a restricted group of agriculturalists as fruit-growers, who may be the heaviest sufferers, it has been estimated that the insect population is at least 80 per cent. useful Of about 600,000 species of insects known to science, perhaps not more than 200 can fairly be called enemies of man Not more than one half of one per cent of all the kinds in the United States are seriously injurious

What constitutes a "pest"? One answer would be that it is any species, whether of generally good, bad or indifferent habits, that gets out of bounds and actually disfigures the face of nature or devours substantial proportions of man's goods. Such infestations formerly resulted chiefly from normal population-rhythms over regular periods of years; they could at least be relied upon to pass quickly Nowadays, in well-settled regions, they are often a product of man's interference with the natural controls; his own short-sightedness deserves the blame, a fact aggravated by the likelihood that his next step may go only further to make the attempted cure worse than the disease The real cure lies in not forgetting the place of enemies that have been preying upon the despoilers for millions of years

A second definition of a pest is an insect that does not belong where it is found. The Hessian fly, which has been called the most destructive insect in America, apparently came to Long Island with the regiments of Hessian mercenaries during the Revolution. The gypsy moth, San José scale and other undesirable aliens reached us at later dates, and have flourished at our expense because they have given the slip to enemies that keep them in check in their native homes. One of the remarkable characteristics of most insects is the high degree of specificity in their feeding habits; many of them depend for their very existence upon some other single kind of organism, plant or animal. When chestnut trees died out along the eastern seaboard of the United States, the chestnut weevil likewise disappeared; when the Japanese beetle reached this continent without its native Asiatic parasites, it waxed unduly strong. The logical way to fight insects is to enlist the services of other insects that eat them, importing the predacious species when necessary.

In recent years a very wide attempt has been made to find methods of artificial control, some of which have been useful, though most of them prove too non-selective when they are applied "in the open" Even electrocuting traps might be of wholly appropriate application under special circumstances, such as in granaries, tobacco warehouses, etc, nor is there any reason why electrified screens should not become important in the elimination of houseflies around stables. The observed results of killing by the lamps, however, make them indefensible for general use on porches and in gardens Dr Frank E Lutz, of the American Museum, once aptly referred to indiscriminate processes for destroying insects as equivalent to "releasing poison gas in a crowded restaurant to kill a hold-up man"

The cautious and responsible attitude of a manufacturer interested in something beyond the mere sale of his product is expressed in the following letter from an officer of an electric company to an entomologist, written in February, 1935

> We have been approached a number of times with the problem of devising insect traps to be baited with blue and ultra violet lamps of our manufacture. We have hesitated so far because we were not entirely sure of the economic

soundness of such wholesale killing, believing that not only the undesirables might be killed, but also there might be a wholesale slaughter of the innocent

To establish a basis of judgment of this economic entomological question, I am asking your advice as to the soundness of the use of the blue or ultra-violet light as a trap bait for methods of protecting some of our plant and tree growths. I hope that you will express yourself freely for I am concerned solely with the fundamental truth in this problem.

What naturalists, as well as the public, need to know is more about the management of insects by purely biological, rather than chemical or mechanical, means. There is also undoubtedly room for research into the great question of new ways in which insects can be made to serve man The silkworm moth and the honey-bee have long been put to a domestic purpose, operators of aquaria and aviaries breed great numbers of the beetle larvae known as meal-worms, as well as certain other insects, to furnish animal forage Relatively little thought, however, has ever been given to the opportunity for making some incidental use of wild insects as a by-product of their economic control Yet I recall one elderly duck farmer on Long Island who practiced an excellent example of this possibility During the mating season he used to imprison numbers of gigantic female Cecropia and Polyphemus moths in cages of wire screen that stood on the ground in his duck pens The scent of the females, carried far down the wind, would cause a constant procession of male moths to fly up and beat eagerly against the screen This also kept a mob of ducks pressing about the cages, snapping at the unfortunate male moths and fattening on their oily bodies Not quite sporting, you may remark, but at least this method of control was reasonable and purposeful. It was not sheer waste

THE RIFT IN THE LUTE

The frequently misunderstood term "balance of nature" refers to a product of trial and error throughout an unimaginably long period of evolution that began ages before man or any of his recognizable ancestors appeared on earth. The climax ultimately attained in the interrelations of climate, soil, plants and animals represents the balance It is not a fixed state, because balance implies a dynamic movability, but it is a fit and desirable condition which endures just so long as no new and abrupt factors enter the field to create an imbalance. Man, of course, has been and is now the chief "upsetter" Part of what he has done has been necessary and more of it hardly avoidable But the belief that "hunches" and slap-dash conclusions arrived at without any fair tests can improve matters that have gone wrong is the most pervasive error in the minds of human beings to-day.

Kill, kill, kill, is the slogan, if there is anything in nature to complain about. Kill, not for sustenance, nor even for decent sport I have before me, for instance, a report on one of the thousands of popularly organized "Varmint Killing Contests" that take place each year in our country. This particular one refers to a county in West Virginia. Twenty-seven different tradesmen, shops, hotels and the mis-named Conservation Commission of the state offer cash prizes for the highest individual slaughter during a shooting term of several months, and the listed "varmints" include foxes, hawks and owls (meaning all kinds, some of which are exclusively beneficial), kingfishers, chipmunks, turtles, water snakes (which rank 500 points), "all other non-venomous snakes" (100 points), and mud-puppies or river salamanders

Many a person whose gorge would rise at the idea of deliberately encouraging the destruction of chipmunks and owls would still be incapable of becom-

ing excited over the senseless wiping out of insects This is because the really desperate battle between man and certain introduced insect pests has been lopsidedly advertised; the association of the name "insect" with something essentially objectionable has become all too deeply ingrained Yet there are scholars to-day who predict that conservational struggles of the not distant future may involve large-scale campaigns for the protection, rearing and transplantation of enough insects to enable man to provide for his own survival! The idea has been developed with the sardonic touch of a modern Dean Swift, yet with a weight of conviction that is not at all funny, by Dr Edith M Patch, formerly state entomologist of Maine.

The instinct of self-preservation makes the best of us callous about the fate of other organisms as long as we can feel that the cause being served is a righteous one. It is therefore hardly reprehensible that the average reader or card-player, sitting luxuriously in the soft glow of an electrified lamp, can listen to the sizzle of each victim as it strikes the grid with a sort of subconscious contentment in which he would be loath to acknowledge any tinge of sadism. Perhaps it is akin to the exultation of the old frontiersmen whenever "another redskin bit the dust." The manufacturers of the lamps are quite willing to take advantage of this specious attitude toward insects, and they would regret wide dissemination of the knowledge that vastly more beneficial than harmful kinds are likely to be slain every time the switch is turned on. The one disinterested fact to be emphasized, however, is that the lamps are made primarily to *sell,* rather than for either the good or evil they may subsequently accomplish

MIND IS MINDING—BUT OR STILL?

BUT!

PROFESSOR LESLIE A. WHITE, in the February (1939) number of THE SCIENTIFIC MONTHLY, has attempted to convince the philosophical world that the so-called "mind-body problem," which has been a chief concern of the greatest thinkers since time began, may be shown to be no problem at all by the simple device of substituting the participial form "minding" for the more familiar substantive, "mind." This is as bold a step on the part of a scientific anthropologist as would be the endeavor of a philosopher to prove by some linguistic legerdemain that the problem of the origin of the human species has no meaning

As a matter of fact, Professor White's suggestion is at least as old as Aristotle, and his analogy that "mind is to body as cutting is to a knife" was actually used by the Stagirite himself And to-day the world is full of psychologists and philosophers who have been saying practically the same thing for years These facts do not make the theory true, however, and all who try to explain away the mind-body problem in this cavalier fashion overlook some important considerations

There are two distinct parts to Professor White's thesis, between which, however, he fails to discriminate, and yet only confusion can result from such a failure We need not quarrel with the assertion of his title that "mind is minding," an activity rather than a thing, but when he goes on to identify "minding" with behavior ("Mind is minding, or behavior")—with reaction to environment —we must demur It is perfectly allowable either to consider "minding" a *variety* of behavior, or to restrict the term "behavior" to overt acts and treat "minding" as a quite different kind of activity, but it is simply fallacious to identify the two types.

Under "minding" are included such activities as thinking, remembering, feeling, desiring, etc ; for as mind is minding, so thought is thinking, memory is remembering (or a name for the capacity of remembering), etc. But such overt acts as walking, talking, climbing, approaching, retreating, etc, belong to an entirely different category from the former Walking, indeed, is a "function of the body," and so are the other activities in the second list; but it is simply nonsense to speak of thinking, remembering or "minding" as "functions of the body," as do Professor White and others of his school. Both these sets of activities are functions of one *ego*, it is true—*I* think, *I* walk, *I* desire, *I* act—but they are two entirely different kinds of functions For one of these sets the word "behavior" is especially appropriate, and for the other set some such word as "mentation" (or "minding," if one prefers); and the words "body" and "mind" respectively refer to that aspect or part of the *ego* which is especially concerned with the corresponding one of these two kinds of activity Whether these should be described as "parts" *or* "aspects" of the self is precisely one of the points at issue between different theories of the mind-body relation; but no amount of verbal gymnastics can possibly eliminate the *problem* of that relationship.

JARED S MOORE

STILL!

PROFESSOR MOORE'S criticism of my paper raises two points (1) Are "mind" and "matter" two different kinds of reality, different entities, or is mind merely a property of matter in cellular (living) form? (2) What class of phenomena shall we label with the word "mind"?

(1) As indicated in my article, all scientific progress in biology and psychology has been made on the basis of the materialistic, mechanistic assumption that "life" and "mind" are merely

properties of matter-organized-in-cellular-form, just as iron or "iron-ness" is a property of one kind of organization of protons, electrons, etc., while "goldness" is the property of another kind of organization of the same sort of particles How "matter"—carbon, iron, calcium, etc —can come to have cellular form and manifest those properties which we call "life" and "mind" is, however, a real problem—to the solution of which "linguistic legerdermain" can not, of course, contribute anything But neither can the philosopher. This is a task for the scientist—the physicist, the biochemist, the biologist

(2) To what class of phenomena shall we attach the label "mind"?

The behavior of any living organism has two aspects· intra-organismal and extra-organismal, *i e*, processes whose locus is within the organism, and reactions between the organism and the environment "Intra-" and "extra-" are merely aspects (not parts) of the integral process which is living Thinking, remembering, desiring, etc, belong to the within-the-organism category; walking, climbing, etc, to the reaction-to-the-environment category Now the question is, To which category shall we apply the word "mind"? Professor Moore wishes to restrict it to the within-the-organism category I wish to restrict "mind" to the reaction-to-the-environment category —with one exception which will appear in a moment. All definitions are arbitrary But some definitions are better than others, better in the sense that one tool is better than another for a given purpose I believe that my definition is the more fruitful one for science

We agree with Professor Moore when he declares that thinking and walking belong to "entirely different categories" We agree also that it would be "fallacious to identify the two" *But,* there is an important point which Professor Moore overlooks Although logically distinct, "mind" and "(overt) behavior" are *biologically inseparable.* Furthermore, the *only way* in which the scientist can observe thinking, desiring, etc, in *all* the lower animals and in *all human beings except himself,* is *in terms of overt behavior*—such as "walking, talking, climbing." The limited and defective observation of *one single mind* (*i e*, one's own, through introspection) is not sufficient for the scientist. Thus, the scientific study of mind (thinking, desiring, etc.) *is and must be*—except for the meager and dubious contribution of introspection —the *study of the reactions of organisms to their respective environments*

The scientist, like the philosopher, insists that his categories be logically valid. But mere logical validity is not enough; his categories must be useful, fruitful, as well To insist, as Professor Moore does, upon keeping "mind" and "behavior" separate and apart is to render the study of mind sterile and to leave the phenomena of behavior unintelligible. It is precisely because the scientist freely employs the data of the one category to illuminate and render intelligible the other—in a sort of cross-fertilization process—that his labors become fruitful Far from being "simply nonsense," the interpretation of mind as overt behavior has shown itself to be the most effective way of studying mind that we have at our disposal to-day. Also, it provides the most satisfactory way of disposing of—if not of "solving"—the mind-body problem

To cherish the "mind-body problem" upon which the "greatest thinkers" have lavished their genius "since time began" without having brought the solution "any nearer now than then" may be dear to the hearts of some philosophers. But to-day, when science yields such abundant and much-needed returns for intelligent endeavor, it seems a waste of time to continue to wrestle with a problem that has defeated "the greatest thinkers" for ages How long should a hen brood on a hard, roundish, white object before she concludes that it is not an egg but a door knob?

LESLIE A WHITE

BOOKS ON SCIENCE FOR LAYMEN

CHILDREN'S SCIENCE BOOKS PUBLISHED IN 1939

THE year 1939 contributed meagerly to the literature of science for children Its outstanding achievement, the revised edition of Anna Botsford Comstock's "Handbook of Nature Study" (Comstock, xx + 937 pp, $4.00) is intended to be used with youngsters rather than by them, unless they are of high-school age This limitation also applies to "Thoreau, Reporter of the Universe," by Bertha Stevens (John Day, xiv + 229 pp, $2 50), although the book is advertised as a selection of Thoreau's writings for "all readers from eight to eighty" Though the selection has given this writer more pleasure than he ever derived from Thoreau's unabridged writings, it still seems beyond the capacities of children under thirteen or fourteen, unless they are guided by adults whose knowledge of nature exceeds their own

"Seeing the Unseen," by Robert Disraeli (John Day, 158 pp, $2 50) is a revision of a book already widely used by children of ten to fifteen years About half its space is devoted to photomicrographs of readily available subjects and half to descriptive text The latter is readable and stimulating, even though it is strongly teleological in tone

Another common fault appears in "Garden Creatures," by Eleanor King and Wellmer Pessels (Harpers, 64 pp, $1 25) This is a very simple, informative and admirably illustrated account of snails, earthworms, beetles, spiders and other creatures of the back yard or vacant lot To the authors, the blister beetle that invades bees' nests is "wicked," and "can hardly be said to lead the life of an honest gentleman" But beetles are not gentlemen If they lead lives that are proper to beetles, why should they be reproached?

The "Boy's Book of Insects," by E. W Teale (Dutton, 237 pp, $2 00) is a straightforward "how to do it" book for youngsters who are old enough to collect, rear and study insects It also contains necessary general information on anatomy, classification and habits of the main insect groups Most of Mr. Teale's readers will be fourteen or older, as will those who use "Our Small Native Animals," by Robert Snedigar (Random House, 308 pp, $2 50) Mr Snedigar tells how to care for frogs, turtles, snakes, mice and a variety of other vertebrates His suggestions will help those who seriously want to keep captive animals, but may discourage persons who think that any odd cage or tank will do for a rabbit, a snake or a newt That such persons should be discouraged goes without saying

Turtles and frogs, in their free state, appear in "Let's Go Outdoors," by Harriet Huntington (Doubleday, Doran, 89 pp, $2 00), though most of this book is devoted to snails, insects and other invertebrates Miss Huntington has successfully put biology—significant biology, not catchy trifles—into language that can be read by second-graders and read to any child of four Her text is accompanied by the best photographs to be found in any science book for children, and the publisher has reproduced them in large size, by rotogravure In all, "Let's Go Outdoors" is the discovery of 1939, so far as children's science books are concerned It is pleasant to know that a companion volume on the seashore, with even better photographs, is ready for the press

R T Peterson's "Junior Book of Birds" (Houghton Mifflin, xv + 92 pp, $2 00) is planned for readers nine to twelve years old, especially if they live in the eastern half of the United States

Illustrations include twenty-four of the familiar Audubon Society color plates, as well as many sketches which illustrate bird attitudes and activities

W. J. Wilwerding has continued his biographies of African mammals in "Tembo" (Macmillan, 138 pp., $2 00). Although he sets out to tell "all that is known" about the natural history of African elephants, Mr. Wilwerding devotes most of his book to elephant hunting and Tembo's marvelous escapes Neither the writing nor the drawing ranks with the author-artist's earlier work, for awkward and stereotyped expressions abound and the pictures suggest stuffed elephants of the old-time museum

In "The Chisel-tooth Tribe" (Harcourt, Brace, 200 pp, $2 00), Wilfrid S Bronson presents a natural history of the rodents, with emphasis on habits, distribution and ecologic relationships All this could be made stodgy, but Bronson's ability to write with humor as well as clarity and balance, plus his clever drawings, have resulted in a book that delights youngsters and adults to whom this reviewer has shown it. One hopes that it will be followed by similar volumes on other important animal groups

Also clever, though not so successful, is "How Father Time Changes the Animals' Shapes," by Gaylord Johnson (Messner, 185 pp., $2 00) It describes the migration and evolution of vertebrates, but Father Time (a malnourished, Neanderthaloid old fellow) and a rolling pin that lengthens necks and legs are not fortunate devices After all, giraffes are not cookies, nor was time, just as time, a causal factor in evolution

As in previous years, the vast resources of archeology have been scarcely touched. "Turi of the Magic Fingers," by H. L Williams (Viking, 172 pp, $1.75), is a routine boy's story of early Magdalenian man, with very crude illustrations. The real Turi, whether boy or man, obviously was a better artist than Mr. Williams, and knew more about the anatomy of animals.

Modern man, as well as astronomy, geology and much else, appear in "The Child's Story of Science," by Uncle Ray (Putnam, viii + 246 pp, $2 50). This is a collection of the well-known syndicated articles by R C. Coffman, edited by scientists at the University of Wisconsin Though necessarily brief, these articles are reliable and well written. So far as geology is concerned, they are vastly superior to "The Book of Stones," by J F Hausmann (Whitman, 33 pp, 50 cents). Here youngsters may learn that all stones come from mountains, that steel scratches quartz, that polyps are mouths, and that rocks were metamorphosed because they laid (*sic*) on ocean beds or under other layers of rock. Most amazing of all, this book and a series of others much like it are "sponsored and copyrighted" by the Board of Public Education, Philadelphia. Can this be science as it is taught in Philadelphia schools?

Still, it is not much worse than "America's Treasure," by W. M Reed, edited by Carey Croneis, of the department of geology, University of Chicago. (Harcourt Brace, xviii + 395 pp, $3 00) Here the author of "The Earth for Sam" undertakes to explain the geology of our natural resources, but becomes hopelessly confused as to processes of sedimentation, uplift, intrusion, dynamic metamorphism and the origin of ore shoots He also makes many errors in routine matters of geology and paleontology, on which reliable information is available in almost every college text-book "America's Treasure" does no service to Mr. Reed's reputation as a writer of science for children and never should have been published.

Conservation, barely touched by Mr. Reed, appears in two other books One

of these "Forestry and Lumbering," by Josephine Perry and Celeste Slauson (Longmans, Green, 125 pp, $1 50), is an admirably illustrated discussion of forestry in various parts of the United States, but is dully written, with nothing to rouse the imagination of children. In "Working with Nature" (Harpers, xv + 181 pp, $1 20), Eleanor King and Wellmer Pessels provide a foundation of nature information upon which they develop a simple outline of wildlife conservation The method makes repeated contacts with the daily lives and observations of children, predisposing them to conservation before that subject is dealt with As in all books by King and Pessels, illustrations are excellent and format is pleasing

In conclusion, we may say that 1939 changed the established picture of science for children only by adding one new and very competent writer who addresses the four- to seven-year-olds It filled none of the obvious gaps in the physical sciences, it produced nothing worth while in archeology, it contributed less in ethnology than did any other year since 1929 It also did nothing to fill the voids left when Seton and Charles G D Roberts stopped work Youngsters who want what those men provided still must use cheap reprints of "Kindred of the Wild," "Rolf in the Woods" or "Two Little Savages"

CARROLL LANE FENTON

PHOTOGRAPHING THE INVISIBLE[1]

INFRARED photography owes most of its value to the differences in behavior of certain materials toward infrared and visible radiations. Many opaque objects are unexpectedly permeable to the infrared, atmospheric haze (but not fog!), human skin, a 6 mm layer of boxwood, sycamore or Siberian pine The converse is not so true, and the transparent substance which is impermeable to the longer, invisible radiations is exceptional. A 1 cm layer of 10 per cent aqueous copper sulfate is an example.

Practical applications of a vast quantity of empirical observations have been made, but as the author points out, only the fringe has been touched The purpose of the present work is to survey the accomplishments, and to describe methods and their underlying principles for the guidance of the practical infrared photographer Dr Clark, who is on the staff of Kodak Research Laboratories, has made numerous contributions to the scientific literature As an example of his lucid style, reference is made to "Seeing the Invisible," SCIENTIFIC MONTHLY, 41 481, 1935

As would be expected, progress has been made since the several-minute exposures by R W Wood in 1910 Due chiefly to the painstaking synthesis of whole classes of complex dyes, comparable photographs can now be made in 1/25 second The author is thorough He depicts the structural formulae of 17 of these sensitizing dyes, and gives the chemical synonyms of popular names, such as kryptocyanine and xenocyanine. He indicates, however, that even the most enthusiastic amateur will do well to purchase his plates and films already sensitized

The photographer who is thinking of entering the field will be gratified to learn that no essentially new technique need be mastered Virtually the same developers, stop baths and fixing solutions are used Adequate formulae for all solutions are appended, and directions for sensitizing ordinary plates, calculated to be least likely to result in disappointment, are included There are mathematical discussions of light and lenses, but these are not essential to a very fair understanding of the infrared method.

[1] *Photography by Infrared* By Walter Clark, Ph D., F I C, F.R P S. Illustrated x + 397 pp $5.00 John Wiley and Sons, Inc 1939.

Some of the practical applications are Examination of paintings for authenticity, examination of documents for alterations; deciphering of faded or partially burned papers, aid to medical diagnosis, investigation of the atmospheres of Mars, Venus and other planets, discovery of new stars, aerial photography.

In the case of paintings, the pigments are of course a complicating factor, but the applicability of the infrared method may be said to depend upon the following fact The refractive index of a hardened linseed oil film increases with age, the effect of this is to increase the permeability of the paint film to infrared radiations

One of the most striking of the illustrations consists of a paragraph in Latin (*a*) by visible light, and (*b*) by the infrared In the former, 9 of the 13 lines are obliterated by the heavy black censorial ink, in the latter the original text is plainly legible How long it will be before the censors start using a better ink is the pertinent question

Another illustration is from a photograph of the Black Hills and surrounding terrain, taken from a balloon at 72,000 feet The curvature of the earth is plainly discernible

One field in which the infrared method will, presumably, always yield negative results is the realm of psychic research The author states that he has frequently been asked to recommend infrared technique for investigating seances, but has never been informed of the outcome; "probably because . . the results are not made public"

The text appears to be free from typographical errors There is an exhaustive bibliography at the end of each of the sixteen chapters, and author and subject indexes at the end of the volume The sole criticism is that the latter seems unnecessarily abbreviated

THOMAS B GRAVE

THE LIFE OF THE MIND[1]

THE history of Freudian psychoanalysis is the story of one of the most remarkable phenomena of the present century. When the basic concepts were enunciated by Freud in 1896 their author was reviled and even expelled from the Medical Society Nothing daunted, he continued his clinical studies and his writing, and soon attracted followers Tremendous resistance was widely manifested by those whose self-assurance was threatened by the revelation of the actual rôle of the emotions and of the instinctive life, the movement and its author were ridiculed and accused of obscenity and worse In much the same way the ecclesiastical authorities raged at the teachings of Copernicus, but the truth made way irresistibly! To-day, despite the determined opposition of the past (and there still remain some doubters!), psychoanalysis has not only exerted a widespread influence upon anthropology, philosophy, sociology and education, but has revolutionized the outlook of psychiatry and has rendered valuable contributions to general medicine, even furnishing the basis for a new field of study, psychosomatic medicine No psychiatrist, whatever his alleged "school" or whatever psychiatric language he may speak, studies his cases without utilizing at least some of the concepts discovered and elaborated by Freud

Dr Hendrick, the author, is a highly competent psychoanalytic psychiatrist, an able student of the field and a writer of great clarity The present volume is the second edition, revised and enlarged, of a work which first appeared in 1934 So rapid have been the advances of psychoanalysis in the past five years that two new chapters have been added, one on the psychological study of organic disease and one on the extramedical applications of psychoanalysis

[1] *Facts and Theories of Psychoanalysis* By Ives Hendrick, M D Pp 369 + xv $3 00. Alfred A. Knopf 1939

The book is divided into four parts, namely, "The Facts of Psychoanalysis," "The Theories of Psychoanalysis," "Therapy by Psychoanalysis," and "The Psychoanalytic Movement" There are also suggestions for further reading, a glossary and an excellent index

The author does not fall into the trap of oversimplification, as many less well-versed writers on the subject have done, on the other hand, he does not encumber the book with adventitious material He deals with the essentials, fully and clearly He is frankly convinced of the value of psychoanalysis and the soundness of its tenets, otherwise, of course, he would not and could not have written such a work Nevertheless, he recognizes that certain principles are theoretical, hypotheses based upon observed clinical data but not perhaps in themselves capable of scientific proof He attempts, in short, to preserve a scientific point of view in his discussion, that this adds much to the value of the book goes without saying

Dr Hendrick has rendered a valuable service to those who are interested in the life of the mind, who recognize that Freud let a flood of light into places hitherto *very* dark and who desire authoritative and readily available information upon Freud's discoveries and methods The book is sound, well-organized, convenient and very readable It is heartily recommended to the readers of THE SCIENTIFIC MONTHLY

WINFRED OVERHOLSER, M D

THE RISE OF CIVILIZATION[1]

OUT of the riches of his knowledge of the archeological discoveries of Northern Africa, Western Asia and Europe, the author paints a clear and entrancing picture of the rise of civilization The story is not a chronological account of the succession of rulers or dynasties of any people or of their wars or conquests. It is rather a discussion of great discoveries that, directly and indirectly through tens of thousands of years from Paleolithic days down to modern times, have given rise to present civilizations.

A preliminary chapter on "Human and Natural History" presents reasons for approaching early human history in much the same spirit as one would investigate the evolution of lower animals, and this is followed by a general description of the elements of cultural progress A chapter entitled "Time Scales" rolls back the curtain of archeological and geological history for nearly half a million years and outlines the measurements of time during the flow and ebb of successive sheets of ice of the Pleistocene

In "Food Gatherers" the author shows how the problem of obtaining food and the discovery of fire started man on his long way toward civilization and the conquest of the world He traces the story through many lands as it is revealed by the remains of bones and stone implements and utensils left at the sites of camps and cave dwellings These advances led to the Neolithic period and revolution, which was followed by the ages in which pottery and bronze came into use, and this progress, in turn, paved the way for the rise of great centers of culture and power, such as those which flourished for several millennia along the banks of the Tigris and Euphrates rivers and in the valley of the Nile The illustrations of the forces which led to the developments of these and other civilizations are extraordinarily abundant and apt

To-day a disturbed world is floundering in uncertainty, vainly trying to understand the present and apprehensive of the future The author's evident purpose is to give a better perspective of man and his problems, and he has eminently succeeded

F R. M

[1] *Man Makes Himself.* By V Gordon Childe $2.50 275 pp. Oxford University Press 1939.

Captn Wilkes

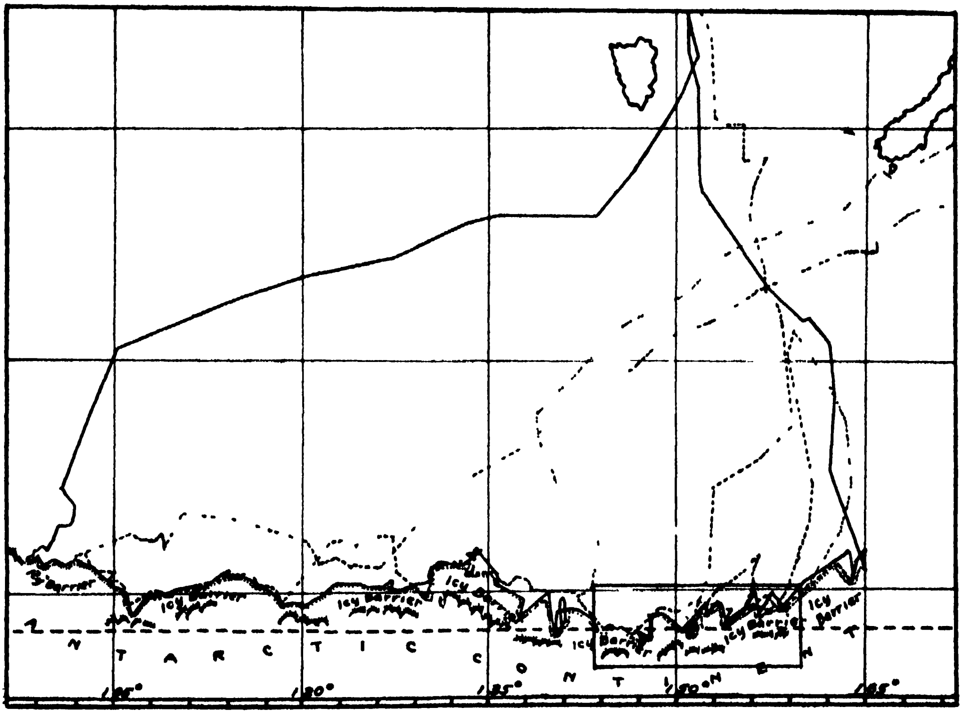
THE PROGRESS OF SCIENCE

CENTENARY CELEBRATION OF THE WILKES EXPLORING EXPEDITION

In the years 1838–1842 a great United States Exploring Expedition, the first to enter the Antarctic region, made extended cartographic and scientific researches within the Pacific area and the then unknown Antarctic region to the south of it. For the extent and the importance of its discoveries, the distinction of its corps of scientists and the volume and authority of its published reports, this expedition bears favorable comparison with the greatest exploring expeditions sent out by the European nations. It might be considered to mark the coming of age of American science.

The American expedition set sail with a squadron of six naval vessels; it was commanded throughout by Lieutenant (afterwards Rear Admiral) Charles Wilkes, and it has generally been referred to as the "Wilkes Exploring Expedition." During January and February of 1840 Wilkes discovered a new coast of the Antarctic fifteen hundred miles in extent, which for the first time proved the Antarctic land to be a continent, and this extended coast, which lies to the south of Australia, is generally shown upon the maps as Wilkes Land.

The perilous cruise of Wilkes along



A SMALL-SCALE MAP OF WILKES' CRUISE FROM HIS REPORT

THE SCALLOP PATTERNS ARE HIS LANDFALLS, SEEN BEHIND THE ICY BARRIER WHICH PREVENTED A NEARER APPROACH.

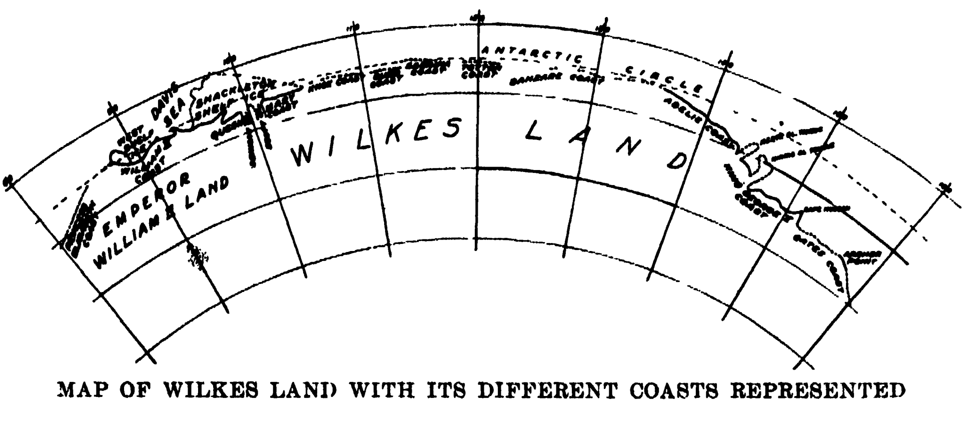
the Antarctic coast was concluded on February 23, 1840, and its centenary was celebrated by a special meeting of the American Philosophical Society held at its hall in Philadelphia on February 23 and 24, 1940 The program of the meeting covered the activities of the Wilkes Expedition, and it included in addition a symposium on American Polar Exploration, both Antarctic and Arctic The speakers were distinguished scientists, explorers and government bureau chiefs, particularly from the Navy Department to which Wilkes belonged and under the auspices of which the expedition sailed

As the Centenary of the First United States Exploring Expedition was thus being signalized, the Second United States Expedition commanded by Admiral Byrd was already in the Antarctic, and the centenary synchronized closely with Byrd's great discovery of new Antarctic land stretching between 96° and 148° west longitude within an absolutely unknown coast which had defied all attempts to approach it This important Antarctic discovery—the most notable in many years—lies outside the hinterland which was discovered by Lincoln Ellsworth in 1935, and it has nearly completed the unveiling of the Antarctic coasts

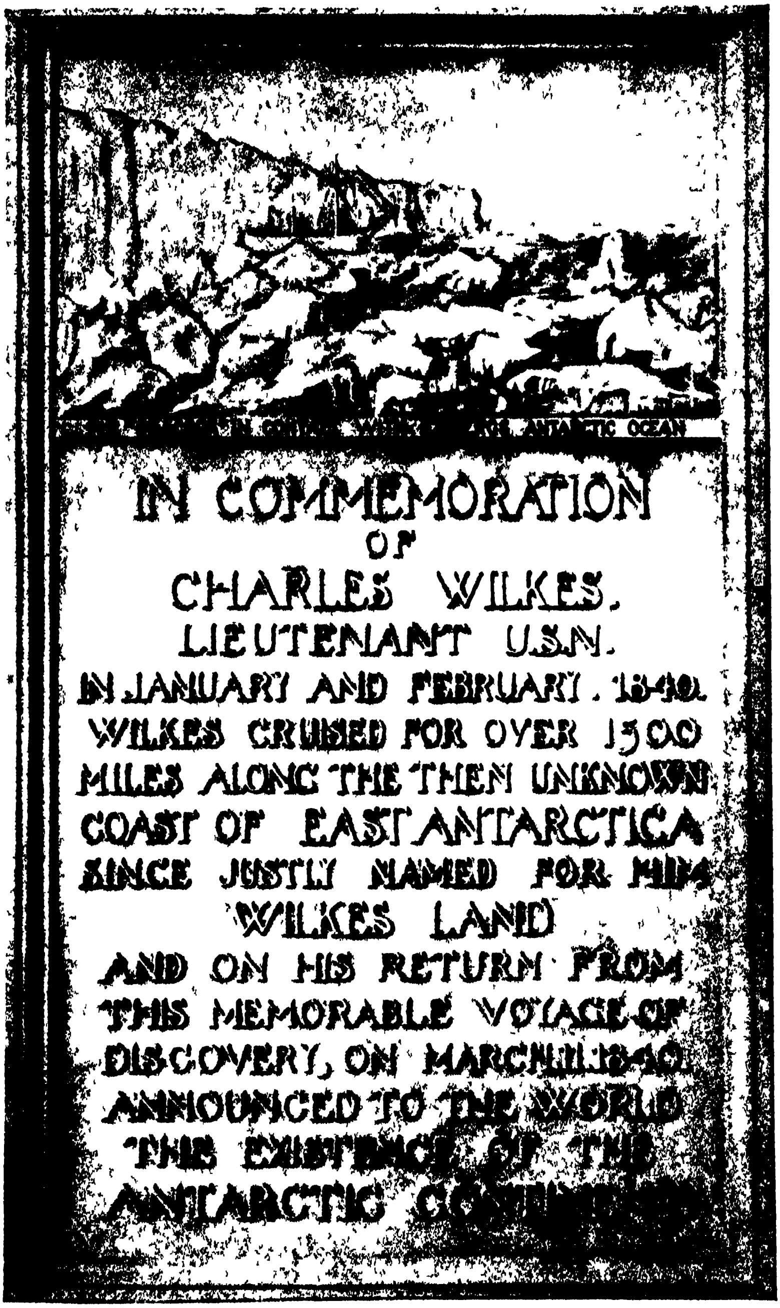
In fixing the program for the researches of the Wilkes Expedition, the American Philosophical Society played an important part, and this relation of the society to the expedition was covered in an opening address by Dr E G Conklin, vice-president and executive officer of the society. The purpose, equipment and personnel of the expedition were treated by Captain G S Bryan, hydrographer of the Navy Department

Wilkes was scientist as well as naval officer, and the final reports of the expedition on meteorology and on terrestrial magnetism and gravity were written by him The volume on physics, which covered magnetism and gravity, though largely printed, had not been published when Congress stopped the appropriations with several volumes still unfinished The expedition's accomplishments along these lines were treated by Dr F W Reichelderfer, chief of the United States Weather Bureau

The most distinguished of the scientific corps on the Wilkes Expedition was James Dwight Dana, who wrote the great volumes of reports on zoophytes, Crustacea and geology While on the expedition, and quite independent of Darwin, Dana evolved the theory of subsidence for the origin of coral reefs and atolls, now the so-called Darwin-Dana theory He also made a classical study



MAP OF WILKES LAND WITH ITS DIFFERENT COASTS REPRESENTED



THE WILKES COMMEMORATIVE TABLET

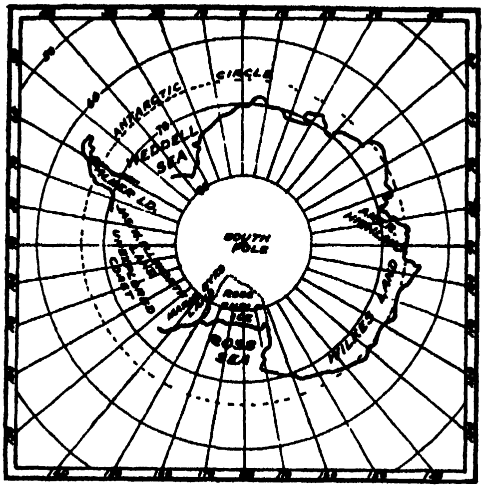
AT THE ROOMS OF THE AMERICAN GEOGRAPHICAL SOCIETY IN NEW YORK CITY (NEGATIVE)

of the volcanoes of the Hawaiian Islands Professor John E Hoffmeister discussed these important researches, Professor Henry W. Fowler treated the fishes collected by the expedition, and Professor Harley H Bartlett the published reports of the other scientists, including two volumes by the great botanist, Asa Gray The discovery of Wilkes Land was treated by William H Hobbs, and the surveys within the Pacific area by Mary E Cooley, of Mount Holyoke College, who for a number of years has been preparing a biography of Wilkes which is now ready for publication

The Wilkes Centenary was largely covered in the session of Friday morning The afternoon session of that day was devoted to American Antarctic Exploration earlier and later than that of Wilkes Palmer, who first discovered Antarctic Land, was treated by Colonel Lawrence Martin, chief of the Division of Maps of the Library of Congress, who recently recovered Palmer's log of the *Hero* Captain Harold Saunders, U S N, discussed the South Pole flight of Admiral Byrd and his exploration of Marie Byrd Land, and Dr W L G Joerg, of the National Archives, the demonstration of the peninsular nature of Palmer Land through Ellsworth's flight of 1935 Professor Earle B Perkins, of the Second Byrd Antarctic Expedition, treated the animal life of the Antarctic with the aid of moving pictures, and in an illustrated evening lecture Professor Laurence M. Gould, second-in-command of the First Byrd Expedition, the glaciers of the Antarctic

The Saturday morning session, which was presided over by President Bowman, of the Johns Hopkins University, was devoted to America in the Arctic A group of Arctic explorers treated the outstanding discoveries in that region,

THE FLAGSHIP, VINCENNES, AMONG THE ICEBERGS
SKETCHED BY CHARLES WILKES ON THE ANTARCTIC EXPEDITION, JANUARY 23, 1840



ANTARCTIC CONTINENT IN 1939
SHOWING AMERICAN DISCOVERIES. THE IMPORTANT DISCOVERIES BY ADMIRAL BYRD DURING FEBRUARY, 1940, ARE IN THE AREA MARKED "UNEXPLORED COAST."

these speakers including Ekblaw, of the McMillan Expedition, Lee, who was Peary's companion on the crossing of Greenland in 1895, Stefansson and Captain Bob Bartlett. General Brainard, sole survivor of the Greely Expedition and now eighty-four years of age, was to have treated the Greely Expedition and the Farthest North of Lockwood and Brainard, but an attack of influenza prevented his attendance. Commander Ellsburgh, U.S.N.R., discussed "The Drift of the *Jeannette* in the Arctic Sea." Captain Bartlett spoke on the "Extended Exploration of Arctic Lands by Peary," which culminated in the attainment of the North Pole in 1909.

The papers presented at the centenary are to be published in a special centenary volume of the *Proceedings* of the society.

WILLIAM H. HOBBS

NATIONAL ZOOLOGICAL PARK EXPEDITION TO LIBERIA

THROUGH the generosity of Harvey Firestone, an expedition has been arranged for the purpose of penetrating the jungles of Liberia to collect wild animals. This expedition, which I have the honor to head, sailed from New York on February 14 on the S.S. *West Kebar*, and by the time this article is printed, will be in Liberia, to stay from three to five months.

The Firestones have long been interested in the national zoo, the late Harvey S. Firestone having presented a pygmy hippopotamus to it about 13 years ago. Harvey S. Firestone, Jr., gave the zoo a Liberian potto, an unusual animal about the size of a kitten, and other animals have been sent to us from the Firestone plantations from time to time.

On a trip of this kind one can never tell what one is going to get; the results are absolutely unprophesiable. Since there is hardly anything at all in the Zoological Park or the National Museum from Liberia, anything we get will be valuable to one or the other of these institutions. I have received innumerable letters from persons who desire to obtain animals for experiment, such as birds for anatomical studies, land or fresh-water shrimp, etc. I expect to find many species of animals, birds and reptiles which have never been taken into captivity, as well as other species which are rare in this country.

There are over 100 different kinds of animals in Liberia, many of them distinct from those in other parts of Africa. The pygmy hippopotamus, as far as I know, is found only in Liberia, although some travelers have reported that it occurs also in the next colony, Sierra Leone. Liberia lacks, however, a lot of the animals found in other parts of Africa, such as the giraffe, hippopotamus and rhinoceros. This absence is, however, made up by the presence of other animals. Liberia has never been an animal-

hunting country like the other countries of Africa

Among the animals which I am particularly anxious to bring back alive are pygmy elephants, pygmy hippopotamuses, red bush cows, zebra antelopes, harnessed antelopes, bongos, flying squirrels and a number of species of cats, such as the West African forest leopard, the golden cat, as well as the fine-spotted serval and the blue serval—large wild cats having long legs and large untufted ears We shall also seek the chevrotain, or water deer, which stands about 12 inches high at the shoulder and lives in the marshes

Brilliant and unusually beautiful birds are to be found in Liberia, including the Tourocou, with unwashable feathers which hold their colors, and kingfishers I want, too, to bring back such birds as hornbills, sunbirds, lovebirds, barbets, black and white crows and interesting storks and cranes

There are a number of reptiles in Liberia the subterranean python, two big vipers (the gaboon and rhinoceros viper) and several kinds of cobras. Chameleons are always an exciting catch, but they have a difficult time surviving the trip home An interesting box-turtle, with a hinge in the back of its shell, land snails six inches long, many insects and waters full of fish help present an interesting outlook for the trip I am taking seines in the hope of catching seldom-seen fish—a few of which I may be successful in getting all the way back home I hope to obtain a complete collection of the fauna

Accompanying me on this trip are Mrs Mann, who is also familiar with wild animals, Ralph B Norris and Roy Jenner, animal keepers at the national zoo

Courtesy Acme Newspictures

TRACING THE ROUTE OF THE SMITHSONIAN EXPEDITION INTO AFRICA

DR CHARLES G ABBOT, SECRETARY OF THE SMITHSONIAN INSTITUTION, HARVEY S FIRESTONE, JR, SPONSOR OF THE EXPEDITION, DR WILLIAM M MANN AND MRS MANN

Our equipment includes ready-made cages which telescope within each other, the last cage containing traps and bird seed Concentrated cod-liver oils and powdered milk are necessary for baby animals, and even Mellin's baby food and honey for certain little birds We carry a motion picture camera in hopes of getting good pictures of the animals as well as of the natives

Monrovia, the capital of Liberia, is our landing place, with headquarters at the Harvey Firestone plantation Perhaps it will be possible to establish a little national zoo here, as we did in East Africa and India

While I have permits from the government giving me full authority to go out, take these animals and bring them home, it is not quite so easy as that sounds, because the animals can not read the permits and do not always offer full co-operation

William M Mann,
Director

National Zoological Park

IMPORTANCE OF GRASSLAND RESERVES

An illustrated article by Dr Victor C Cahalane, entitled "A Proposed Great Plains National Monument," describing a typical grassland region, will be printed in one of the forthcoming issues of The Scientific Monthly

It is estimated that about 40 per cent of the area of the United States represents original climatic grassland It is likely that our dependence upon the grassland areas of the world will become greater instead of less as time goes on Concerning their fundamental economic importance to mankind there can be no question

This circumstance has tended to accelerate their exploitation, at the same time that it brings into sharp relief our need to understand them better than we do Because good grassland is richly productive when first exploited, it has passed through a cycle of mining and destruction quite comparable to that suffered by the virgin forest One who is not trained to distinguish changes in vegetation structure or floristic composition can not realize this as readily as he can understand the meaning of cut-over or burned-over forest land. To-day it is increasingly difficult to find areas giving an adequate picture of original grassland communities To such an extent is this true that there are still to be found sharp differences of opinion regarding the proper nomenclature of some of the grassland communities

What is true of the vegetation is of course even more true of those other constituents of the grassland communities—their native animals In the opinion of the animal ecologists who have been advising the National Research Council, it is necessary to have undisturbed areas of considerable extent, suitably buffered by additional natural areas, in order to achieve anything like the necessary restoration of the natural plant and animal interrelationship

The layman might perhaps infer that an enterprise of this kind is largely sentimental or of such remote practical import as to represent self-indulgence for interested scientists That such an enterprise would have many intangible values is not to be questioned, but in addition results that are direct, important and practical may be expected to follow the establishment and study of extensive natural grassland areas

On some continents, once-productive grassland regions will no longer support human communities There is ample evidence that this could happen in North America If we are to forestall

WIND EROSION NEAR LITTLE COLORADO RIVER

SHOWING ITS EFFECT UPON VEGETATION. THE WIND EDDIES AROUND THE HUMMOCKS AND THE ROOTS HAVE BECOME EXPOSED AND SAND IS BURYING THE STRUGGLING GRASS. IN 1857 BEALE DESCRIBED IT AS BEING "COVERED IN ABUNDANT AND EXCELLENT GRAMMA AND BUNCH GRASS."

BARREN LAND NEAR WINSLOW, ARIZONA

BROUGHT ABOUT BY OVERGRAZING AND ERODING WINDS. BEALE REMARKED IN 1857 THAT "FOR STOCK OF ALL KINDS I SHOULD SAY THAT A BETTER COUNTRY IS NOT WITHIN THE UNITED STATES."

WASTED LAND IN NEW MEXICO

THE GRASS HAS DISAPPEARED, AND IN ITS PLACE HAS COME UNPALATABLE SNAKEWEED. SHEET AND GULLY EROSION ARE AT WORK. EIGHTY-ONE YEARS EARLIER BEALE WROTE THAT IT WAS "A GRASSY VEGA OF ABOUT ONE HUNDRED AND SIXTY ACRES, WHERE THE WATER AND GRASS ARE GOOD AND TIMBER ABUNDANT—CEDAR AND PINE."

FERTILE LANDS NEAR FLAGSTAFF, ARIZONA

VERDANT AND PRODUCTIVE LAND CONSERVED THROUGH CONTROLLED GRAZING

such an outcome we can expect to do so only by energetic measures based upon a realistic knowledge of the grassland environment in all its aspects It is well established that the best integration of the many complex factors in an environment is represented by the natural living communities which it has supported Grassland communities, moreover, not only express their environment but are the agency which has been responsible for its present capacity to support human communities These natural communities have steadfastly elaborated materials and transformed solar energy This has resulted in the relationship known as soil, which, with water, is so largely the measure of the capacity of an environment to support life

The net result of human occupation to date has been to arrest and reverse these constructive processes Permanent human occupation demands the ability to create a constructive relationship analogous to that represented by the work of the natural communities Until we know how to do this and can get it into operation, there is no type of scientific investigation of more fundamental importance to our continued use of the grassland than a study of how the natural communities do the thing which we, as yet, can not do

PAUL B SEARS

ENDOCRINE GLANDS AND THEIR DISORDERS

THE Twelfth Annual Graduate Fortnight of the New York Academy of Medicine, held from October 23 to November 3, 1939, was entitled "The Endocrine Glands and Their Disorders" The purpose of the Graduate Fortnight is to instruct the family doctor in the latest developments of scientific medicine and to enable him to learn their application to his practice from the leading experts of the nation More than a thousand physicians participated in the lectures, round-table discussions and exhibits

The general plan of the fortnight was as follows Each evening one or more experts reviewed the present state of our knowledge of one of the endocrine glands On four mornings round-table discussions were held in which an opportunity was given the doctors to have their questions answered by the lecturer or another expert As a background for all this the rooms and halls of the beautiful Academy of Medicine building were converted into exhibit halls, where photographs, charts, x-ray pictures, anatomical specimens and apparatus were shown

The opening lecture was delivered by Dr H M Evans, who sketched the historical development of our knowledge of the endocrine glands

Dr J B Collip, known to the world for his work in the isolation of insulin, reviewed the functions of the pituitary gland This gland has been called the leader of the glandular symphony because it is the master gland and controls the functions of almost all the other glands Dr Leo M Davidoff presented the clinical states that result from diseases of this master gland An increase in function may cause excessive growth and the production of giants, while decreased function of this organ is responsible for the tiny dwarfs and "living skeletons" that amuse us in the circus or the theaters

Dr Leopold Lichwitz discussed the diseases due to simultaneous involvement of the pituitary gland and its nervous connections in the base of the brain These include the most marked cases of obesity and an unusual disturbance known as diabetes insipidus in which an afflicted

person may drink as much as 56 pints of fluid in a single day

Dr J H Means, H T Hyman and Frank H Lahey discussed disorders of the thyroid gland Diminished function of the gland results in obesity, dry skin and hair, as well as mental and physical torpor Overfunction of the thyroid causes persons to be abnormally alert and active, very nervous and often to have a goiter and "pop-eyes"

Dr Robert Loeb outlined our knowledge of Addison's disease This malady, due to destruction of both adrenal glands by tuberculosis or some other disease, results in profound weakness, intestinal disturbances and a most striking bronzing of the skin of the sufferer, who may become as black as a Negro

Dr Solomon Silver presented a series of "bearded ladies" who are known to the lay public only as circus attractions, but afford the endocrinologist some of his most baffling problems He pointed out that not one, but several, glandular anomalies can bring about this sad fate for the feminine victim

Five investigators detailed the effect in both sexes of the sudden or gradual loss of function of the sex glands In women this brings about the well-known and often troublesome period of the "change of life" The very annoying physical and mental symptoms of this transition can now be effectively controlled by the use of ovarian products to replace the function of the failing ovary. In the male, experiments indicate a restoration of sexual vigor by the use of a preparation that replaces the function of aging or absent testes

It was the opinion of those who listened to these ten evenings of lectures that a comprehensive and instructive survey of the field of the endocrine glands had been offered to practicing physicians and that in doing it the New York Academy of Medicine had rendered a valuable service to them

SOLOMON SILVER, M D

DISPELLING FOG

FOG is the most serious menace to aviation and one of the greatest hazards to shipping However, like everything else, it is not an unmixed evil—it clears the air of dust and microorganisms The problem is to overcome its ill effects where it is disadvantageous and to welcome its benefits

As Dr Karl T Compton, president of the Massachusetts Institute of Technology, has recently announced, the scientists of M I T, in cooperation with those of other institutions, have been investigating the properties of fogs for the purpose of overcoming their disadvantages Instead of looking for some magical method of dispelling fogs, they first investigated their properties They found that in an average fog on the coast of New England the amount of water in the droplets of which fogs are composed is only about one sixtieth of that which the air contains as invisible vapor In a space 1,000 yards long, 100 feet high and 200 feet wide, which would have to be cleared for safe landing of an airplane by visual means at the time of an ordinary fog, there is about 30 tons of water, 1,000 pounds of which produces fog Evidently no simple and inexpensive method can dispose of so much water

The scientists found that there is no chance that any light radiations from the invisible ultra-violet to the equally invisible infra-red, can penetrate fogs to any considerable distance They did find, however, that very short radio waves, of the order of two centimeters in length, produce resonant electric currents in the minute fog droplets These currents heat and evaporate the droplets, causing a hole through the fog Unfor-

tunately, no sufficiently powerful source of such short radio waves has been made, and at the best the method would be costly

It is well known that calcium chloride absorbs water—it is, in fact, one of the best drying agents To make effective use of this property, a spray of concentrated solution calcium chloride was sprayed from nozzles distributed along pipe placed horizontally at a distance of 50 feet or more above the ground As the spray fell slowly through the foggy air it took up enough water vapor to reduce its humidity below the point at which the fog droplets would evaporate. The fog vanished as if by magic, and as the breeze carried the treated air along, a clear corridor from 100 to 200 feet wide and from 50 to 100 feet in height was produced This would be sufficient for the safe landing of planes guided by a radio beam until they entered the clear space But to produce the clear space would cost about $5 per minute Fortunately the means of guiding planes safely through impenetrable fogs are rapidly being improved F R M

AVERAGE USE OF MECHANICAL POWER

At various times in the history of the world a high state of civilization of a relatively small part of a people has rested on the work of slaves As in Greece, the slaves outnumbered the free men five to one, and the ratio may have been greater in Imperial Rome when she was at the zenith of her power

In these days civilizations depend on the use of mechanical power The average use of mechanical energy for the whole world, advanced peoples and the primitive, adults and children, is the equivalent of about 50 man hours of labor for every day in the year In the United States the average is more than twice as great

Various reasons have been ascribed for the deterioration of earlier civilizations, such as moral degeneration, lack of religion, use of dictators, invasion of barbarians, political corruption, mosquitoes, exhaustion from wars, etc May there not have been a more fundamental reason? We remember the glorious achievements of the few, forgetting the ignorance and degradation of the many. At no time was the average high When civilizations failed, probably what really happened was that the few who glistened for a moment on the crest of the waves were swallowed up in the level of the deep above which they temporarily rose More literally, the fundamental biological processes relentlessly pursued their way and the many who served the few were the parents of their successors

Modern civilizations are essentially different from the ancient In spite of the claims of demagogues, slaves have been banished by machines and the base of a civilization has become essentially the entire population Consequently there are good reasons for hoping and believing that, even though there should be disorders and wars, there is no serious danger of another sinking of humanity into chaos and barbarism Machines carry no genes that may corrupt the stream of life of our successors

F R M

THE SCIENTIFIC MONTHLY

MAY, 1940

THE PEASANT PROBLEM IN YUGOSLAVIA

By Dr RAYMOND E. CRIST

SECTION OF GEOGRAPHY, UNIVERSITY OF ILLINOIS

Ye friends to truth, ye statesmen, who survey
The rich man's joys increase, the poor's decay,
'Tis yours to judge how wide the limits stand
Between a splendid and a happy land
—*Goldsmith, "The Deserted Village"*

INTRODUCTION

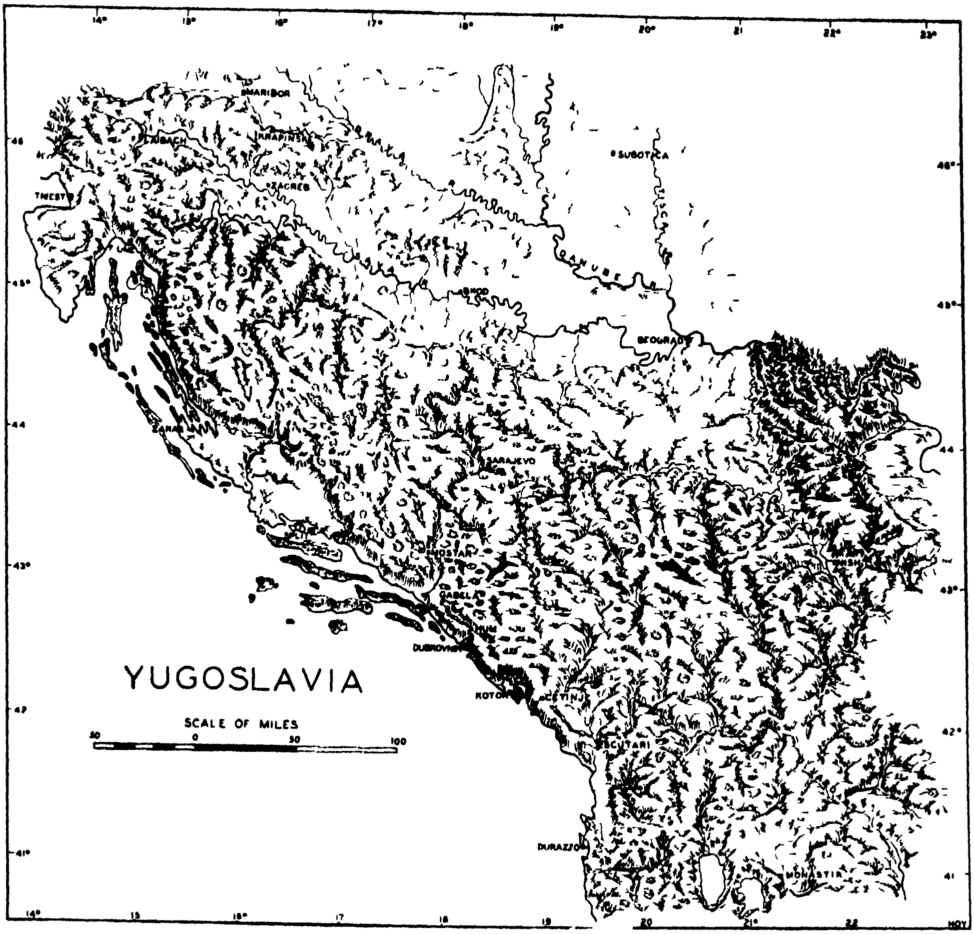
THE Balkan region, long notorious as the "cockpit of Europe," is characterized by a deep-seated restlessness and instability Probably because of the war, all seems quiet for the moment, but almost anything may relight the fuse, and irredentisms will again become assertive, and governments again be overthrown at record rates Turbulence, feuds and corruption are indeed the heritage of centuries of Turkish misgovernment, but these evils have been accentuated, if anything —especially since the World War—by the conflicting Near Eastern policies of the Great Powers

For hundreds of years the Balkan area has served as a roadway for many people of varied racial strains who migrated from the steppes of Russia and from Asia Minor into Europe, with the result that national lines are notoriously vague For example, there are many cases of small cultural islands made up of one human group, surrounded by people of an entirely different racial strain, who speak a different language, have a different religion and cultural heritage But this has not prevented the growth of militant nationalisms Each group, whether relatively pure or obviously mixed racially, jealously maintains its heroic legends, and feels that it has a mission to fulfil Very often the groups have been encouraged in their demands by some interested Great Power, and all too frequently missions of rival nationalisms have clashed Many post-war political units contained several minority groups, each of which remains true to its cultural traditions, its language, its religion And each longs—or is encouraged by propaganda to long —for reunion with its homeland.

THE CROATIAN PEASANT AND HIS HISTORICAL BACKGROUND

In an attempt to analyze some of the developments in the Balkan area as a whole, it is proposed to make a rather intensive study of conditions in a typical "Balkan Case"—Yugoslavia—particularly of conditions affecting the Croatian peasants, who form some 80 per cent. of the population in the Croatian province Perhaps it will be possible to reach conclusions that will be valid for other countries of southeastern Europe

The Croatian peasant is, like most peasants, generally conservative, but not culturally backward Since he has been close to the soil for centuries, he is stolid and rather hard to change, but when he does have a good idea and comes to value



Topographic diagram by Harry E Hoy and used with his permission

RELIEF MAP OF YUGOSLAVIA

it, he will cling to it tenaciously, even if he may suffer by so doing Out of the love for his piece of land and his village there has grown up in him a love of country which is nationalist in the truest sense of that word Even under the dictatorship he unfurled his Croatian flag with little regard for persecution which he was to suffer at the hands of the Beograde régime In spite of differences in mentality in the various parts of Croatia, there is one characteristic common to the entire people, namely, their willingness to fight for their old rights (*stare pravice*) against all odds

The peasants in pre-war Croatia and Slovenia vegetated under a feudal régime similar to that prevalent in western Europe during the Middle Ages Great landed estates were the rule, and the great land-owners were the highest court of appeal for the peasants on their land The peasants were serfs, bound to the soil They paid the landlords in crops and personal services This serfdom (*Kmetstvo*) was abolished only after the war There were very few free peasants (*slobodnjaci*)

In Dalmatia and Istria there existed a modification of the feudal system There

the peasant rented the land and gave part of the crops in payment—in other words, he was a share cropper. This system, with its familiar abuses, has by no means disappeared, in spite of the laws of 1925 and of 1929 which were passed primarily to abolish it. In Bosnia and Herzegovina also the feudal pattern existed, but there the landlords were Moslems—a condition resulting from the Turkish invasion Christians could be only serfs or free peasants—not landholders In 1915 there were 96,000 serfs, 151,000 free peasants and perhaps 10,000 Bey and Aga families (landlords) The free peasants were almost all Moslems Serfdom was abolished after the war, but the agrarian reform was carried out in such a way that the peasant class was impoverished and the arable lands greatly reduced compared to what they were before the war

Post-War Agrarian Reform Breaking up of Great Landed Estates[1]

In the provinces of Slovenia, Croatia-Slavonia and Voyvodina there were 720 great landed estates with a total area of 1,277,040 hectares (3,154,300 acres), of which 555,137 hectares were expropriated Titles to 367,084 hectares of this land were given to 312,175 families, who were living on these estates at the time of expropriation This means that only a little more than a hectare (2 47 acres) was received by each family In addition, 8,736 families were brought in from other areas and settled on 41,497 hectares, or 5 hectares per family, 7,289 families of war veterans of different classes received title to 52,344 hectares, or 7 hectares per family, and finally, 13,059

[1] Dr Josef Marz, "Jugoslawien, Probleme aus Raum, Volk und Wirtschaft," pp 41–43, Berlin, 1938

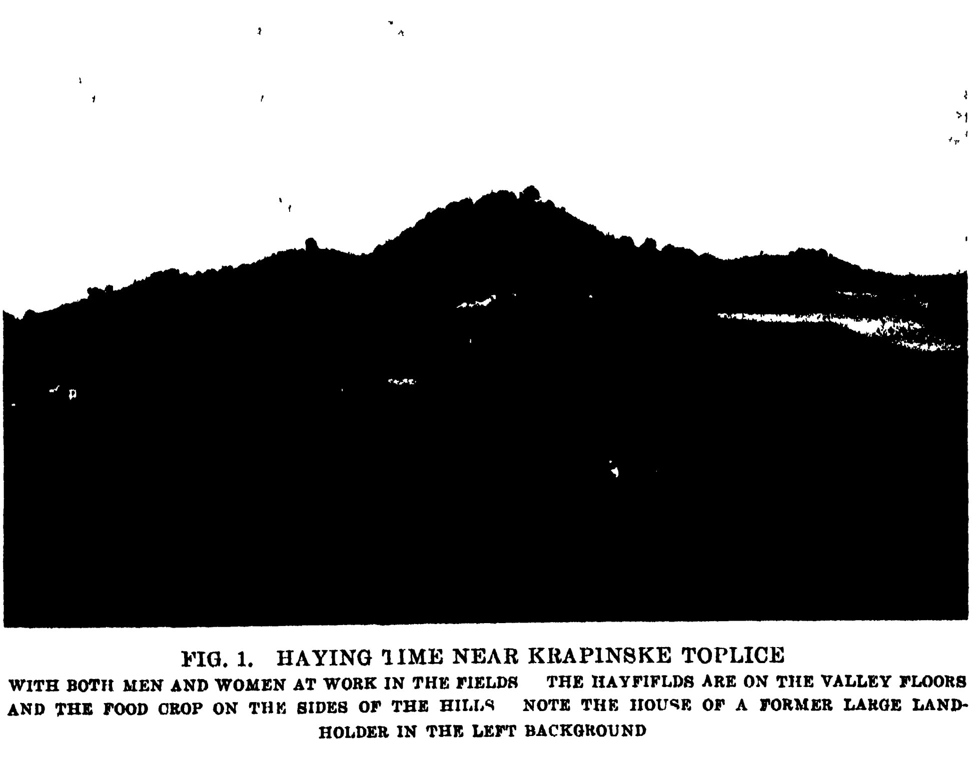


FIG. 1. HAYING TIME NEAR KRAPINSKE TOPLICE

WITH BOTH MEN AND WOMEN AT WORK IN THE FIELDS THE HAYFIELDS ARE ON THE VALLEY FLOORS AND THE FOOD CROP ON THE SIDES OF THE HILLS NOTE THE HOUSE OF A FORMER LARGE LANDHOLDER IN THE LEFT BACKGROUND

FIG 2 RURAL SCENE NEAR KRAPINSKE TOPLICE
WHERE THE WHITEWASHED HOMES OF THE PEASANTS ARE NEAR THEIR FIELDS

families of new settlers of various categories were given 94,212 hectares, or about 7 hectares per family

In Dalmatia the share-cropper system was abolished—at least on the statute books—and 97,000 families were given possession of the land they had long cultivated—50,000 hectares, almost all of which was in very small plots planted in grapes

The great feudal estates of Bosnia and Herzegovina were divided up among various classes of people First, the 217,000 families who were already farming the land were given 1,227,028 hectares, or an average of 6 hectares (15 acres) per family, while 28,294 families of new settlers received 36,784 hectares, an average of only 1½ hectares (3 7 acres) per family, an area obviously much too small The 4,483 war veterans received 22,515 hectares, or 5 hectares (12 4 acres) per family

Social conditions were largely responsible for these reforms With years of war behind them and starvation staring them in the face, many peasants were ready to fall upon the great estates and divide up the land without benefit of government decree The peasant war veterans who had become accustomed to violence and the use of force and who had heard vague rumors about what had happened in Russia, clamored for land, and in no uncertain terms To these discontented classes the new government threw land reform as a sop and gave the appearance of legality to what the peasants were ready to do violently Little heed was given to economic considerations, and the plots were often too small Moreover, many landlords then felt relieved entirely of any responsibility towards the peasants on their lands. To be sure, they had never given them much thought, the reform was an excuse for giving them none at all Furthermore, the landlords were paid, at least in part, and they con-

FIG 3 NEVER FAILING CROP—CHILDREN OF ONE PEASANT FAMILY
SLAVIC TYPES THREE CHILDREN WERE ABSENT, GATHERING FIREWOOD AND TENDING THE COWS

tinued to live. After what had happened in Russia they were glad to preserve their lives, together with a part of their prerogatives, and to prevent a violent revolution of the peasantry.

Peasant Life Near Krapinske Toplice

The little village of Krapinske Toplice is set in a frame of intensively cultivated rounded hills. This is a densely populated area of Tertiary hill lands, on the slopes of which woods and fields under cultivation form pleasing patchwork patterns and at the foot of which streams meander sluggishly through hay fields and pastures. The whitewashed homes of the peasants are another note of beauty in this picturesque cultural landscape (Fig 1).

One of the first things that strikes the eye of the observer is the hay fields on the valley floors and the food crops on the sides of the hills, some of which are steep, the reverse of what one would expect. In this region, only hay will thrive on the valley floors because they are poorly drained and swampy, a condition due to the fact that the Sava River and its tributaries have reached a temporary base level at the mountain barrier through which the gorge of the Iron Gate has been cut. Only after this obstacle has been eliminated and the streams above it have cut down to a new base level can the valley floors be drained. This factor plays a part in the economy of the region at present, but, as we shall see, it is by no means the most important one.

Relatively few peasants live in the villages, for they prefer to have their homes on or near their fields. Their main food crop is corn (maize), which grows well in the hot summers and which can be raised with beans and pumpkins under a system of interculture, thus materially increas-

ing the yield of foodstuffs per acre Both men and women work long hours in their fields during the summer (Fig 2) There are few fences, except along roads. The small plots of wheat are cut by hand, every stock being carefully gathered, there are no gleaners, because there is not one head of wheat lost

In this rather primitive rural economy children are considered an asset, not a liability Families of eight or ten living children are common, in spite of a very high rate of infant mortality (Fig 3) Of course, the peasant knows nothing of birth control methods, and probably if he did he would not care to practice them Furthermore, a child becomes a valuable part of the economic unit in a short time He tends cows along the roads or between the fields at a very tender age, so that every bit of hay can be saved for winter use He can also collect and carry home small branches of trees for firewood, and later can cut them into suitable lengths for burning

The lives of these peasants are certainly meager in the extreme They seldom have meat to eat—hogs, calves, chickens and ducks must be sold for cash, as well as milk, butter and cheese in many cases And these products are sold—if a buyer is found at all—in a buyer's market At the little hotel in Krapinske a peasant was asking 15 dinar (one dinar equals approximately 2 cents in American money) for a big fat duck—and was unable to sell it even at that price Excellent cheese that must have required months to make sold for 15 dinar the kilo The man of all work at the hotel—interpreter, bell-hop, janitor—received his keep and 300 dinar a month for his services His tips amounted to perhaps the same amount On this he had to support his wife and four children at Zagreb. Their standard of living can be imagined As he pointed out, he was very unfortunate in having four daughters, for boys would go to work very young and help out at home. Furthermore, it would be no easy task to marry off the daughters because he could give them no dowries.

The land in this area rates only as fourth class for the country as a whole It is well divided among the peasants There are 8,000 people in the county and 4,890 hectares of cultivable land This means on the average only a little more than an acre per person—a much too small acreage in a region where subsistence farming on poor land is about the only means of making a living Some 4,000 persons have emigrated to foreign countries or to other parts of Yugoslavia, and send some money back to their families The ten largest landholders have a total of only 86 hectares But these 8,000 people must pay some 75,000 dinar in taxes to the local government and 125,000 to the Federal Government This averages 25 dinar per person per year, and we shall see later what a burden taxes are to the peasantry as a whole

Practically all work is done by hand, because the peasant has little money with which to buy tools and is almost on a subsistence basis Even to obtain the minimum cash with which to buy the few industrial goods, such as foodstuffs and agricultural implements, which he can not do without and which he can not produce himself, he must sell half or even more of his crops The rest is eaten by himself and his family Under such conditions the possibility of capital accumulation is remote Hence, there is almost no chance of buying up-to-date farm implements and fertilizer, or of introducing new farming techniques

Sarajevo and Environs

Far to the south of Krapinske Toplice, around the city of Sarajevo, the peasants are comparatively well off But first a few words about the town

The site of Sarajevo is an alluvial terrace of the Miljacka River, which is set in an amphitheater of low hills made into

FIG 4 STREET SCENE IN SARAJEVO
TWO OLD MOSLEMS, WITH A MOSQUE AS BACKGROUND, DISCUSS THE PRICE OF HAY

irregular patterns by fields under cultivation These fields are separated from each other by green ribbons of oak trees, elms and beeches The beauty of the natural landscape is heightened by the peaceful contact of the oriental Moslem world with the occidental Christian world The groups live harmoniously together, with no proselytizing at all and very little intermarriage Every day is market day, and any street may serve as a market place for farm produce On a bridge across the river, with a picturesque mosque as background, two old Moslems begin the long-drawn-out process of mutual capitulation necessary before two muleloads of hay may change hands (Fig 4)

West of Sarajevo the valley opens out on the extensive terrace of the Zeljeznica River, a turbulent mountain stream from the southeast which here suddenly loses its velocity and begins the process of aggrading its bed The little peasant villages of Lasica, Hrasnica and Kovaci cluster along the edge of the high dark mountains like beads on a string In such places the houses do not take up space on the fertile terrace, and the peasants in summer are able easily to go out to their long narrow plots (Fig 5)

These peasants also have herds in the mountains, which rise immediately behind the villages (Fig 6) Transhumance is practiced with numerous head of sheep and goats, as well as cattle, horses and mules, which are pastured in the mountains during the summer and brought back to the village in winter Hay for winter feeding is grown just at the foot of the mountains and on the gravelly areas of the terrace Some of the peasants keep bees Poplars, oaks and fruit trees—especially plums—are planted in the villages and along some of the roads. In the slack season the peas-

ants may cut logs or firewood, or burn charcoal in the mountains for sale in Sarajevo (Fig 7), where there is a good market for farm and forest products the year round The government-run resort of Banja Ilidza is a good market in the summer time, and many of the nearby peasants are engaged in intensive garden agriculture Thus peasant life here is fairly well integrated, largely because of the possibility of diversification and proximity to good markets Furthermore, urban industries, such as carpet-weaving, leather-tanning and basket-making, absorb some of the surplus rural population

Mostar and Environs

In going south and west from Sarajevo along the Neretva River the continental type of climate gradually gives way to the Mediterranean The Mediterranean influence is particularly marked in the vicinity of Mostar (Fig 8). This town grew up where the Neretva River has cut a gorge in resistant limestone, where it could easily control the river crossing as well as the trade up and down the valley The sun, in the summer, shines down mercilessly upon this little town in its setting of limestone mountains Figs, olives, grapes and pomegranates ripen along the stream on terraces of recently deposited gravels which have formed conglomerates The presence of these fruits announces the proximity of the Mediterranean, as do the stone houses of the peasants, agglomerated in a few villages

On the limestone mountains themselves, sheep crop the sparse grass and shrubs, and the poverty-stricken peasant lives in a stone house which blends perfectly with its surroundings He grows potatoes and a few vegetables on tiny plots protected by stone walls The peasant wife busies herself with spinning

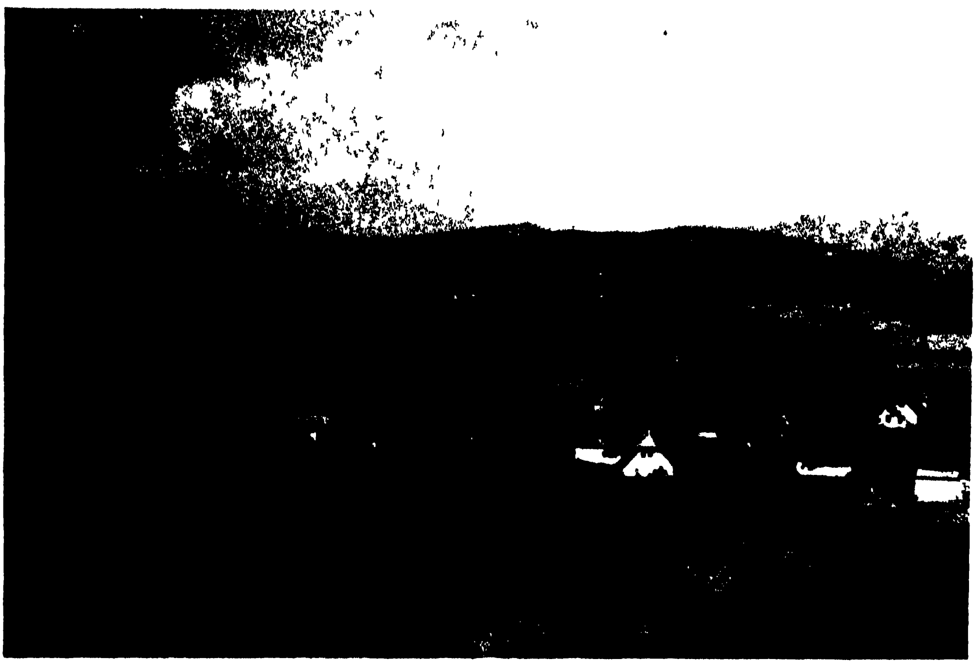


FIG 5 THE VILLAGE OF HRASNICA NEAR SARAJEVO
LONG NARROW PLOTS UNDER PEASANT CULTIVATION ON THE FERTILE SOIL BEYOND HAY IS GROWN IN LESS FERTILE SOIL IN THE FOREGROUND IN THE LEFT FOREGROUND IS A ROW OF BEE HIVES

woolen thread as she walks along on one of her rare trips to town to market a little surplus produce or to buy some meager supplies (Fig 9) A short distance downstream from Mostar the valley widens, the terraces are more extensive, and wheat and tobacco are grown Here the peasants have a slightly higher standard of living than immediately around Mostar

THE POLJE LANDSCAPE AND THE HUMAN RESPONSE

A continuation of our journey to the Dalmatian Coast across this Karst country takes us through the Polje River valley, which has given its name to a type of landscape that is unique in the world The Popovo Polje is a valley in the form of a great flat-bottomed trough which stretches for some thirty miles between the towns of Gabela and Hum and through which the Mostar-Dubrovnik railroad has been built During the winter this entire valley is filled with water to a depth in places of 100 feet or even more and forms a sort of finger lake Since the underlying rock is limestone, the river has no surface outlet and the water gradually seeps away in the course of the winter All that can be seen of the river in summer is a bright ribbon meandering across valley bottoms, as flat as a billiard table and noted for their fertility (Fig 10) The fields are laid out as regularly as the squares on a checkerboard, and are planted mostly in corn In the upstream valley bottoms, which dry up first, corn may be knee high when it is just being planted near Gabela, where the river ends by going underground

The peasants have built their villages on the alluvial fans along the valley, high enough to be safe from the winter flood Here they overlook their corn and to-

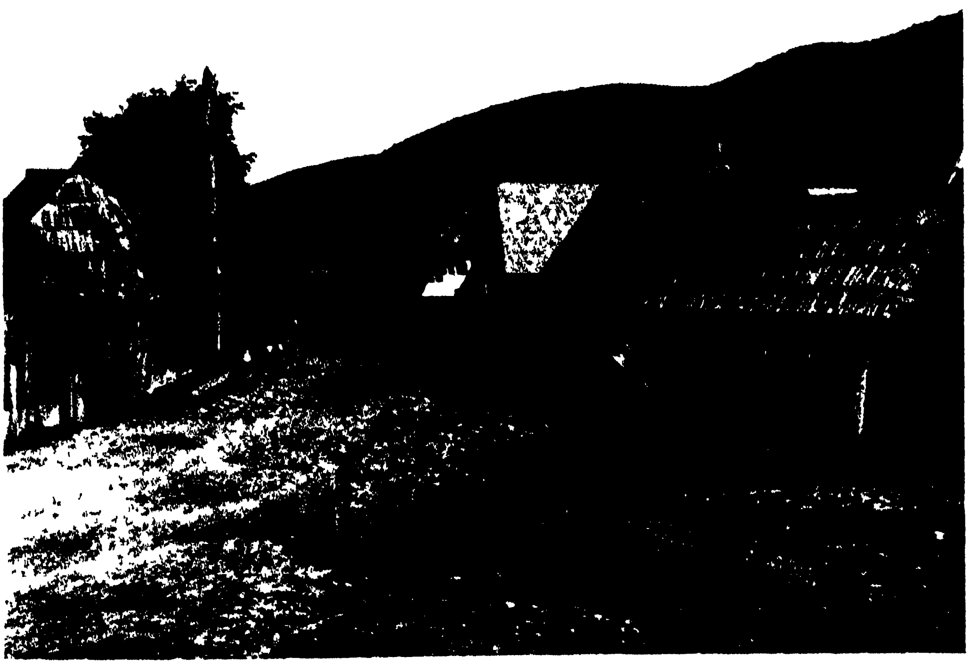


FIG 6 VIEW DOWN MAIN STREET OF THE VILLAGE OF LASICA, NEAR SARAJEVO HOUSES OF WOOD, WITH VERY STEEP CLAPBOARD ROOFS NOTE HEAVILY WOODED MOUNTAINS IN THE BACKGROUND

bacco fields on the valley floors, and are near their vineyards and fig and olive groves which grow on the terraced fields of the alluvial fans (Fig 11) Behind them rise the mountains of Mesozoic limestone, where sheep and goats, tended by the children, crop the sparse xerophytic vegetation Wool from these animals is made into homespun clothes for the entire family, and if there is any surplus, it is sold for cash or bartered for food products The peasants live a life of local self-sufficiency Little cash is used, and that which is obtained goes mostly for taxes

The Doline Landscape

In most of the limestone areas of Dalmatia there are many isolated depressions which have no visible outlets, especially during the last few hours of a journey to Dubrovnik During long periods of time rain-water has collected in them and gradually seeped out below, leaving a little soil in these sinks on which a few peasants eke out a meager existence (Fig 12) The main crops on the very small plots, on which an infinite amount of time is spent, are wheat and potatoes Every one eats as much as he can of these crops till about Christmas time, when the supply begins to run low. Then the family hog is killed, after which there is plenty to eat for a few days The meat that is not eaten fresh is smoked in the house This is not a difficult procedure, since the house has no chimney, the smoke from the meager fire of small twigs finds its way out through the low door Constant breathing of the smoke-filled air is hard on the lungs, and there is small wonder that so many peasants in this region suffer from tuberculosis During the season from harvest till shortly after Christmas, when food is plentiful, many peasants gain from 20 to 30 pounds in weight But then comes the season of lean meals, when the main dish for months is soup made of rascik—a kind of coarse cabbage which resists

FIG 7 STREET SCENE IN SARAJEVO
TWO MOSLEM CHARCOAL VENDORS IN FROM THE MOUNTAINS PEDDLING THEIR PRODUCT ON THE RIGHT IS ONE OF THE SPLENDID VEGETABLE AND FRUIT MARKETS FOR WHICH THE CITY IS NOTED.

FIG 8 A VIEW OF PART OF THE CITY OF MOSTAR

WITH ITS BACKGROUND OF MOSTAR, AND OF LIMESTONE MOUNTAINS, ON WHICH A FEW SHEEP AND GOATS GRAZE THE MEDITERRANEAN INFLUENCE IS SEEN IN THE BARE LIMESTONE MOUNTAINS, THE TERRACED ALLUVIAL SLOPES, AND SUCH CROPS AS GRAPES AND OLIVES CONTRAST THESE MOUNTAINS WITH THOSE IN FIG 6

the cold winter wind from the continent, the *bora* On this diet the peasant is able to keep alive till spring, when he begins to till the fields again

There is a division of labor within the household The man grubs the soil, plows and cares for the farm animals, if any The woman cooks, takes care of the children spins, weaves, knits and also serves as a pack animal She helps bring in the harvest and carries the grain to the mill to be ground—sometimes great distances

Peasants who can live in such an environment and thrive are tough They often make excellent students if they can only get to a school But even with an education they may find it impossible to get work The field of medicine is to some extent preempted by the sons of doctors, and that of law, by sons of lawyers Hence an educated peasant may be forced into free-lance journalism and from there into politics He is dissatisfied with his lot and with the lot of his people at home He feels that he thinks better when asleep than do those peasants without the advantage of an education when wide awake Therefore he must awaken them He points out that they live on a very low plane, that the Beograde régime is not at all interested in their plight, and that local autonomy would do a lot toward solving their problems Since the peasants can see very little good that the central régime has done them, they fall in line, feeling that any change would be for the better

DALMATIA, THE YUGOSLAV RIVIERA

At last we reach the heights overlook-

FIG 9 A PEASANT WOMAN
IN MOSTAR TO BUY SUPPLIES, ABSORBED IN HER TASK OF SPINNING WOOLEN THREAD

ing the Dalmatian Coast and gradually descend to the port of Dubrovnik, a beautiful city of the Middle Ages on this picturesque Riviera, flanked by vineyards and cypress trees

Dalmatia is a narrow strip of land which runs for some 300 miles along the Adriatic, with several hundred islands close to the mainland This is the classic Karst region, with only here and there a bit of level fertile ground along the coast, always flanked by dull gray limestone mountains which are quite arid, with that complete "lifelessness" which characterizes the landscape of the moon Wherever the mountains stand back from the shore, little villages have grown up in the midst of tiny terraced fields and garden plots—some no larger than a square yard Vineyards, fig, orange and olive groves stretch in places for miles along the coast The reddish brown of the terraced fields, the dark green of the vineyards and the dusty gray limestone mountains are a never-to-be-forgotten sight

But the peasants are poor—very poor Tremendous labor must be expended if they are to eke out the barest living from their tiny plots Fourteen hours of labor a day are usual in the summer-time, and a man can be hired to work these hours for fifteen dinar and food During the off-season he probably works for the government, but even then he puts in eleven hours for only twelve dinar

A great deal of wine was once made along this coast and shipped to Vienna and the highly industrialized centers of the old Austro-Hungarian empire, a market which has been hermetically sealed by the erection of high tariff walls Furthermore, there are the taxes. Wine must pay a 10 per cent transportation tax if it is moved from the place where it was produced The result is that less and less is made In many instances the vines have been pulled up

and the plots planted in potatoes or wheat, which the peasants consume at home Tobacco is a government monopoly, and a peasant must buy a permit in order to raise it But since the cost of the permit is almost prohibitive, a great deal is grown illegally The government seems to ignore the fact that trade brings wealth By putting prohibitive taxes on many products the peasants are driven to the most primitive sort of self-sufficiency

THE DEVELOPMENT OF COOPERATIVES

In many of the countries of Europe the modernization of agriculture has coincided with a development of collectives When the peasant has to change the economy from that of the local self-sufficiency of a feudal estate to a money economy, agricultural production must change Formerly he raised only what he needed, and if there was a surplus, the marketing was done by the landlord, now he must produce for the market and dispose of his produce himself In order to do this he must have enough capital to introduce new and more intensive methods of production There is now less emphasis on labor, more on capital Hence the peasant must have credit, but therein lies the danger. He can get credit from the banks or from the local money lenders Since as a rule the government agencies tend to finance only the well-off peasants or great landlords, the small peasant is driven to seek credit from the local money lender, whose rates are very high Since the peasant often can not make enough to pay the interest, not to mention the principal, he soon finds himself in debt, working for his creditor or creditors instead of for himself This condition con-

FIG 10 THE POLJE RIVER NEAR GABELA

WHERE IT DISAPPEARS UNDERGROUND NOT TILL EARLY JULY DOES THE SOIL GET DRY ENOUGH TO WORK NOTE STONE HOUSES WITHOUT CHIMNEYS IN THE FOREGROUND

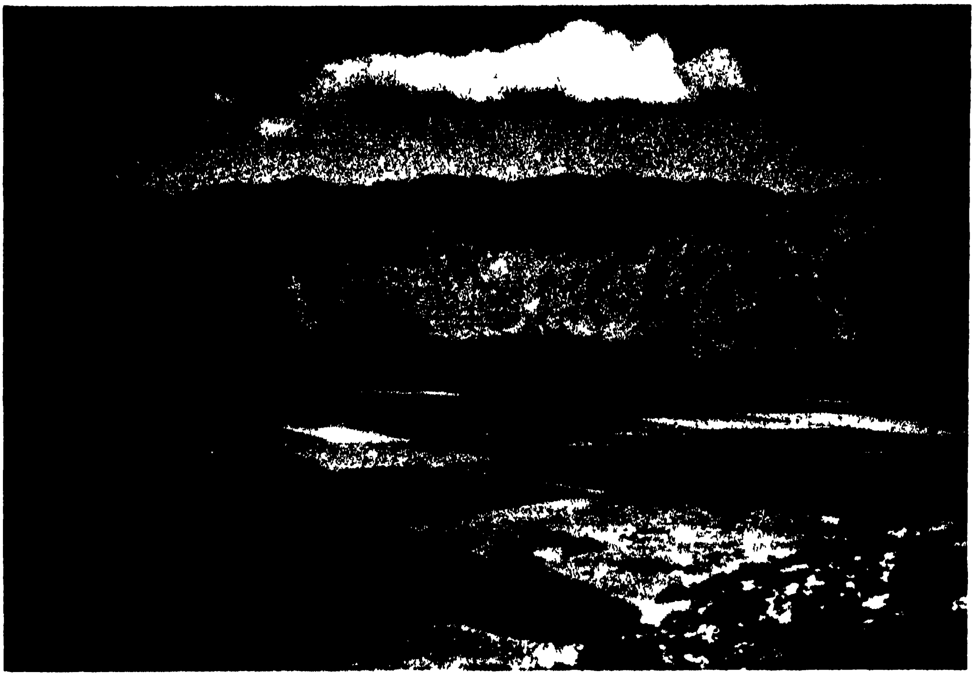


FIG 11 A VIEW ACROSS THE POLJE VALLEY NEAR HUM

HERE THE PEASANT VILLAGES ARE LOCATED ON THE ALLUVIAL FANS IN THIS UPPER PART OF THE VALLEY THE CORN IS ALREADY SOME TEN INCHES HIGH

tinues till his plot of land comes under the hammer in order to pay his debt Then he joins the proletariat in the city or becomes a day laborer in his village A great many peasants have met this very fate, although they have attempted to defend themselves against it in many ways, one of the most important of which has been the development of collectives

In former times there existed in Croatia a kind of patriarchal community organization of society All the grown male members of a tiny community chose the head man ("gospodar," gazda), who was vested with a great deal of authority, but who could be deposed as soon as the majority felt that he was no longer furthering the best interests of the community unit Thus the peasant has had a sense of a truly democratic scheme of life, in which society is so ordered that it expresses the will of the people—at least of those in his community They like to have some one in authority as long as he can be recalled when he no longer truly represents their interests But now the authority of the gospodar has been assumed by the state, which is not so easily changed

Most of the farm units of Croatia are very small, and these necessitate work in common much more than the large undertakings The small holders are dependent upon each other to a great extent, for only by close cooperation can they harvest and market their produce Cooperation was not new, since the peasants had long lived under the patriarchal system in which one or more families worked their land in common Each member, irrespective of age and sex, had a right to the use of the common property Socially the "zadrugé," or collective, was a community bound to-

gether by blood ties, economically it was a collective Long before the war there was a well developed system of these local cooperatives Unfortunately, after the war many of them were captured by aggressive modern business men who thereupon usually managed them to their own narrow advantage But the will to cooperation is still in the heart of the peasant, which is very important. A discussion of the development of the co-operatives would be a volume in itself [2] Suffice it to say that membership in the cooperatives has been increasing steadily each year, but that they can not yet supply the leadership and capital that it was hoped they might, in time, as has been done in Denmark

In Russia after the revolution the state farms for awhile cultivated only 25 per cent of their crop land, the remainder was rented out or worked by peasants on a share-cropping basis. It is to be noted that they employed and fed twice as many workers per unit of land for a given area as did the private estates before the revolution [3] And from 1936 to 1938 the planned area under spring crops on the collective farms in the Soviet Union increased by 18,000,000 acres because they continued to show that they were more efficient producers than the state grain farms These results would seem to point the way for the Yugoslavs Emphasis should be on the collective farms, since the increase in that form of farm unit should certainly mean a higher standard of living for the present population

[2] Dr. Vilko Rieger, "Das landwirtschaftliche Genossenschaftswesen in den Kroatischen Ländern," Berlin, 1939, Verlag Rudolph Pfau

[3] W Ladejinsky, "Soviet State Farms," *Political Science Quarterly*, 53 1, 63, March, 1938

FIG 12 A DOLINE OR LIMESTONE SINK NEAR HUM

HERE THE WATER COLLECTS AFTER RAINS AND GRADUALLY SEEPS AWAY BELOW THE SURFACE ON THE TINY PLOTS OF SOIL A FEW PEASANTS MAKE A VERY POOR LIVING

FIG 13 A VIEW ACROSS THE POLJE VALLEY

ABOUT HALF WAY BETWEEN GABELA AND HUM HERE THE FIELDS HAVE BEEN PLOUGHED AND PLANTED THE TINY PEASANT VILLAGE IS LOCATED ON THE ALLUVIAL FAN, HIGH ABOVE THE VALLEY BOTTOM, WHICH IS FLOODED IN WINTER

Present Indebtedness

The amount of indebtedness of peasants is very great, 700,000 of the 1,780,000 of them in Croatia, or 32 5 per cent, being in debt to the extent of between 6 and 7 billion dinar The average indebtedness for those holding up to 19 hectares is 7,000 dinar, from 10 to 30 hectares, 22,000, from 30 to 75 hectares, 63,000, and from 75 to 100 hectares, 70,000 By far the greater number of debtors are peasants with small holdings The average indebtedness increases with the size of the unit, and is greater in those areas of advanced agriculture because more credit is necessary there The state banks and the cooperatives have granted somewhat more than 50 per cent. of the credit (43 per cent and 12 per cent, respectively) The rest (45 per cent) is obtained from the private lenders, whose interest rates are as high as the traffic will bear But the very fact that peasants will trust themselves to the tender mercies of these loan sharks shows what a crying need there is for capital During the worst depression years there was a tremendous demand for credit for consumer goods Fortunately, the collectives were in a position to meet much of this demand and thereby improve the condition of the small peasant Furthermore, by giving some competition to the private money lender, the collectives were able to keep the interest rates somewhat lower generally than they otherwise would have been

Seven tenths to four fifths of all the debts at the banks have been contracted by peasants In the autumn of 1936, under the régime of Stojadinowitsch, a moratorium was declared on all these

debts. But if the peasants are ever to pay this money they must have markets for their produce. If their debts are permanently cancelled the banks will cease to function. Where further capital is to come from is the burning question.

THE TAX BURDEN AND THE PEASANT

Before the war 11 kilograms of wheat sufficed to pay the taxes to the state on a "Joch" of land, whereas now it takes on the average 26 kilos. When the local, county and village taxes and the indirect taxes on consumers goods are added to those due the Federal Government, it is apparent that the peasant could not pay them even if he wished. In 1928 the government stepped in and passed a law regarding indirect taxes based on the prices of farm products in 1925–1926. Although prices sank as much as a third or even a half, the taxes remained the same. According to the official statistics for the fiscal year 1936–1937 the federal taxes averaged 438 dinar per person, to which 104 dinar in city and county taxes must be added—542 dinar per person This is the average for the entire country, but the tax rates are higher in Croatia than in Serbia. It is estimated that each citizen pays the state on the average at least one third of his entire cash income in direct or indirect taxes.[4] For the peasant class the percentage of cash paid to the government is even higher, and this is one of the most oppressive burdens the peasant has to bear. In some poor districts the tax collectors have stopped peasants coming from town and taken what money they had, since it was a foregone conclusion that every one without exception had back taxes to pay. To avoid this the money was frequently given the children, who went home by circuitous routes.

Hence most of the ready cash goes to the government, and the peasants have no money to buy manufactured goods. They are generally quite poorly clad. Matches may be an unheard-of luxury, and if the kitchen fire goes out coals must be obtained from a neighbor to start another. During 1932–1933 thousands of homes used no sugar or matches. And at the same time that there was almost no market—or ridiculously low prices—for their hogs, sheep and other farm produce, a large part of the peasantry was chronically undernourished. A high percentage of those examined for the army are unfit for service, and the percentage of those fit decreases each year. And the rate of infant mortality is very high—one of the highest in Europe.

Because taxes remained fixed despite the steadily falling prices of agricultural products, the collectives tried to have them lowered. Attempts at negotiation with the central authorities were first made, but without success Then the peasants simply refused to take their produce to market till the taxes were lowered. This had the desired effect in some areas, particularly in those where the officials had been selected from the locality. The peasants were not only successful in getting taxes lowered, but they gained confidence in their collective strength as well. However, this action was less successful in the wine-producing areas of Dalmatia, where the officials are not chosen from the local communities, but are appointed in and come from Beograde Hence they were not interested in local conditions or in trying to lower the taxes to a level at which payment would be at least remotely possible.

With reference to the policies of the central government, I will quote from some of the closing paragraphs of one of the most penetrating and prophetic books ever written on any European country—"The Native's Return," by Louis Adamic.

The (Yugoslav) people, I mean the mass of plain people, with few exceptions, are splendid,

[4] Dr. Otto von Frangeš, "Die sozialokonomische Skrutur der jugoslawischen Landwirtschaft," p. 118, Berlin, 1937.

capable of great sacrifices, the best human material with which the rulers of a new state could start if they honestly and intelligently planned to create a good, progressive civilization In point of rulers, however, Yugoslavia, like all the rest of the Balkans and most of Europe, could be in no worse plight. The Belgrade government is part of the post war political gangsterism in Europe But for the support it receives from the Western powers, the people of Yugoslavia would have swept it into the Danube and the Sava long ago As it is, it continues to oppress or discourage nearly every virtue in the country. . But eventually the vitality now suppressed is sure to burst its bonds Meantime, it will enable the people to endure all the evils and misfortunes with which the immediate future seems ready to smite them This goes not only for Yugoslavia, but all Slavic countries in the Balkans and eastern Europe

And again,

I see now that the salvation of the Yugoslav people and other small backward nations in that part of the world lies, clearly and inescapably, in the direction of Russia They will have to overthrow their present racketeer rulers, from a Balkan or East European federation of collectivist national republics and, in some mutually satisfactory way, attach themselves to the USSR.

And indeed the reappearance of Russia in the Balkans has given Yugoslavia courage to resist Nazi demands. The country has no desire to increase its exports to Germany unless it is sure of payment, and it demands payment in goods that it needs and can use. It no longer wants to be a dumping ground for any and all surplus goods Germany may have on hand, regardless of quality. Yugoslavia's attitude has stiffened markedly since Rumania failed to receive the goods which the Reich promised it last spring.

In other words, the country is in the process of internal Balkanization as a result of short-sighted government policies. In a half-hearted effort to foster ownership of land by the peasants, the government has destroyed security of tenure. The result is an uprooted peasantry ready for any change that might again stick their roots deep into the earth that they have tilled for centuries.

But a bold peasantry, their country's pride,
When once destroy'd, can never be supplied
—*Goldsmith, "The Deserted Village."*

PLANT ROOTS CONSERVE SOIL

In order to determine the relative efficiency of various cultivated crops in prevention soil erosion, Dr Howard J. Dittmer, of Chicago, has investigated the root systems of several plants The results will be surprising to those who are not familiar with the aggressive fight plants make for life

It was found that the average number of roots in each cubic inch of soil in the top six inches ranged from 80 for soybeans to 2,000 for Kentucky blue grass The total lengths of the root hairs of soybeans in a cubic inch averaged 40 feet, and in the case of blue grass more than 4,000 feet. The total surface area of the root hairs in a cubic inch averaged only 3 5 square inches, while in the case of blue grass it averaged over 200 square inches These figures are a measure of the contact of these plants with the sub-surface world as well as of their power of presenting soil erosion. F. R. M.

ORGANISM, SOCIETY AND SCIENCE

II. SOCIETY

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IN turning now to the epiorganism, I must confess at once no technical competence, yet I venture to examine how successfully our knowledge of individuals may be extended to give insight into higher order orgs in which they are units. Comparisons between societies and organisms are common enough and many familiar words and phrases imply their likeness[3]. But these are too often similes and metaphors based on highly superficial or strained resemblances rather than on true analogies or homologies. Even if the organism were but a model for the society it might be thought-provoking, for the resemblances must be based on certain common principles of organization and operation. The burning fuse and the activated iron wire are models of a nerve carrying an impulse exactly because the basic mechanism of transmission is alike in all, and study of the models has greatly furthered our understanding of the nerve.

But I can not concede that the organism is merely a model for the epiorganism any more than is the cell for the organism. If a society is an org at all, and this can hardly be denied, it is related to the organisms of which it is

[3] This essay was deliberately written without consulting the literature of sociology and so stands as an example of what can be done in the way of sociological analysis from a strictly biological approach. Since its completion, it has had the careful consideration of professional social scientists to whom I am most grateful for many stimulating criticisms and suggestions. The few of these which, to avoid misunderstanding, seemed to demand inclusion in the body of the paper are clearly set off in parentheses or footnotes.

The most consistent questionings of this approach have been: The idea of a social organism was developed by Hobbes and Spencer but was never satisfactory and has been relinquished by sociologists, and even assuming valid comparisons between organism and epiorganism, of what explanatory or predictive value are they in the understanding of human societies? As to the former, it is surely significant that a great body of biological knowledge, accumulated entirely since the early efforts to extrapolate from the individual to the group, fits in ever greater detail the society of to-day, itself evolved not inconsiderably from that of Herbert Spencer. It even directly refutes some of the more formal objections raised to this comparison—that only social units are mobile and spatially separated, play multiple roles, possess freedom of action and the like. At one time in scientific history it was also insisted that physics and chemistry could not usefully be applied to biological problems because of the new and different "vital" qualities of organic bodies not represented in inorganic matter.

This leads to the second point, viz., the possible utility of such an approach. If biological considerations merely helped to set the limits within which social actions and structures could develop (as thermodynamic knowledge tells only what physico chemical events can occur, not which ones will), it would be valuable enough. But I suspect from my own brief experience as a sociological dabbler that much more than this is possible. In discussion with social scientists, I found without exception that the seemingly non technical words and elementary concepts of one discipline were not understood by a follower of the other. Not understood in the most serious way, for each of us had a perfectly good set of connotations for the words we used in common, but these meanings differed enough to obstruct communication, yet sufficient discussion nearly always brought clarification and constructive agreement. Further, it carries some promise that a sociologically untutored biologist can be led by his technical knowledge of the multicellular body to conclusions about societies reached after long study of them by distinguished sociologists. I have had much personal pleasure in discovering that I have "rediscovered" parts of the work of Le Bon, McDougall, Cooley, Trotter and Durkheim, as examples.

composed, and in turn to their cells, as an org of order $N+1$ is to an org of order N, and as it is in turn to an org of order $N-1$ Since emphasis has been placed mainly on the differences between orgs of different order, upon the supposed emergence of new qualities, I find no word to express this relation of similarity It is a type of homology,[4] perhaps "hierarchial homology" conveys the import; and the epiorganism and organism are hierarchical homologues Their likenesses, then, when correctly seen, must have a deep significance indeed, and the transposition or extrapolation of knowledge from one to the other may lead to valid inferences which are far more than clever word pictures.

The greatest difficulty is perhaps in merely identifying the epiorganism Between cell and organism exist many intermediate orgs—as tissues and organs, and from organism on, many others—family, neighborhood, occupational or other special group, town, nation, race, entire interspecific ecological community. In the less evolved cases, the epiorganism is fully as definitive as the organism. one colony of bacteria; one volvox ball of several thousand cell organisms; one Portuguese-man-of-war, a single cluster of hundreds of attached individuals which have differentiated into several types; one termite nest; one herd of deer or flock of geese; one isolated nomad tribe of Indians or Arabs. But an org is only semi-isolated from its environment, and the more open the interchange between them the more likely is the org to find itself incorporated in another of greater compass When, in addition, the org itself is poorly integrated, the boundary becomes quite uncertain For example, it is often a matter of choice where a line is drawn between one sponge with several lobes and several separate sponges So a small backwoods village may remain to-day a fairly discrete epiorganism, while even a much larger town really in the social milieu is as clearly only part of one

The question also arises of interspecific relations, especially that of symbiosis A lichen is often considered to be an organism though composed of many algal and fungus individuals A termite, except for one group, can not digest the wood it eats; this is done by symbiotic protozoa which inhabit its gut, and the sterile insect starves to death. Ants keep aphids as man does cows. There is little more reason to call a termite and its intestinal flora an epiorganism, than to call a man and his flora one But the epiorganism which is an ant-hive might well be considered to include the commensals, and certainly human societies would be quite altered by the absence of their domesticated animals (not to mention plants!). In last analysis, all living organisms are closely enough related to one another in function (aside from descent) to constitute collectively a great epiorganism But it will be more useful to consider mainly human groups and to focus attention on the modern industrialized nations as epiorganisms A comparable analysis of termite colonies has been made by Emerson

The Epiorganism

The epiorganism has definitely evolved and shows at any moment vestiges of its phylogenetic past. Our language, structures, habits carry archaic elements, as our body carries its appendix. We shall later examine the directions of change. Any individual epiorganism has also an

[4] Biologists will prefer "analogy" to "homology" here, when both are used in their technical meanings· Homologies resemble one another by virtue of common origin despite the lesser differences resulting from divergent function; analogies, despite different origin, have been forced by like function to converge in their characters. I have chosen "homology," though less defensible on this basis, to avoid the other connotations carried by "analogy" and which might misdirect the thinking of the non biological reader.

ontogeny which roughly recapitulates the phylogeny of that species of epiorganism and is similar in separate individual cases. Groups of American Colonials, striking over the mountains westward, each independently passed through hunting, agricultural, crafts and industrial stages; while, conversely, Chinese, Malay, European and other peoples which colonized various Pacific islands, each reproduced more or less exactly its parent epiorganism (This is not meant to imply that each new community retraces all earlier cultural epochs; nor does the embryo recapitulate the history of its species in constant or extensive detail.) Social inheritance may be as compelling as that transmitted *via* chromosomes, and the unit which has differentiated under one set of conditions may be quite unable to alter under a second Further, the epiorganism adapts to its effective environment The material structures it produces, the social relations developed, the mores of behavior of its units, are strikingly different in arctic or tropic climates, in plain or mountainous terrain, with peaceful or warlike neighbors or none at all, with much or little land, water and other natural resources

The epiorganism is, of course, living, an animorg, and it manifests the major characteristics of other organisms. Dynamic equilibrium is self-evident; from day to day and year to year the social group maintains itself far more constant than does any individual in an equal time span, and this equilibrium depends upon continuous action. Its environment is tapped for free energy and a chemical stream flows through it. As the metabolism of a metazoan organism is directed to supplying its cells with nutriment, so does that of the epiorganism do so for its units. And new epiorgan systems come into being more or less hierarchically homologous to respiration, digestion, circulation and excretion—ventilation, meat packing, canning, restaurants, water and gas plants, freight and trucking, sewage and scavenger systems

Specific synthesis of living and nonliving units is also obvious The growth curve of a population is similar in shape to that of an individual. New units are produced by a form of autocatalysis—metazoan reproduction shares the basic characters of this—and other substances and structures are formed by simple catalysis Cell walls, woody tubes, chitin, shells, bony and calcareous spicules, connective tissue fibres—like buildings clothes, tools, roads—are formed by the living units, acting sometimes singly and often in cooperation The honey-comb, built by hundreds of organisms, exhibits the same mathematically perfect minimal surface and maximal volume relation as does the nautilus shell built by hundreds of cells or the foraminifera skeleton built by one A young mammal raised on a calcium deficient diet can not construct its levers and trusses of bone but must use the poorer cartilage; the organism grows abnormally, functions, *e g*, moves, by different means, and may not survive A young epiorganism of a "species" normally using iron, kept on an iron-free diet, can not build its tools and structures of iron, but must use the poorer wood or some "ersatz" material, and it develops abnormally in organization and function.

And adaptive amplification is likewise manifested by the epiorganism, though we shall hardly be surprised if this is at a relatively primitive stage. Foreign trade and manipulated currencies, trade treaties and customs' barriers, diplomatic intercourse and, especially, war are normal or emergency responses of the society to other epiorganisms, to its biotic environment. The coordinated behavior of a nation in response to acute internal (or external) disasters—hurricanes, floods, epidemics, earthquakes—affords especially clear examples of

adaptive amplification; though the less striking adjustments to more common stimuli—new inventions, ideas, problems—which accompany the gradual evolution of the epiorganism, are more common and more important. And it is obvious, of course, that society responds as a single org, though final action is performed by unit individuals (as the muscle cells in an organism), for these actions are almost all meaningless except in relation to the whole organization. Pulling a drowning man from the flood has significance at the organismic level, mailing a check to the Red Cross or sending typhoid vaccine by airplane, only at the epiorganismic one

Individual persons are the "cells" of the epiorganism and classes of them performing like functions, vocational groups, are the tissues The cells constituting an animal tissue are by no means always segregated spatially or grouped in some way. Fibroblasts, reticulo-endothelial cells, lymphocytes, each collectively forms a tissue, but the individual units are scattered, often singly, among cells of other types all over the body Such dispersion is rather more common in epiorganism tissues, but there is no sharp difference introduced by the question of location Similarly, no new problem appears with the use of non-living materials in tissues, *e g* , wood and bone tissue are largely dead, as are the binding fibres of connective tissue.

It is possible to draw innumerable analogies between tissues in our bodies and epitissues in our society, but many of them are not proper hierarchical homologies. The same valid or semivalid pairings can be made between organs, built of interrelated tissues, and epiorgans. Muscle cells can be paired with laborers, farmers and soldiers; gland cells with merchants, manufacturers, cooks and housekeepers; epithelium with architects and engineers, builders and clothiers and with their products, white blood and reticulo-endothelial cells with doctors; red blood cells with postmen, handlers of trucks, trains and boats and with their implements, bone, cartilage and the simpler connective tissues with dams, bridges, roads and the men who build them; nerve fibres with clerks, stenographers, messengers and telephone operators, nerve cells with administrators, judges, politicians, priests; receptors with reporters and scientists and perhaps creative artists—these are some of the pairs of tissues and epitissues that suggest themselves.

Hierarchically homologous organs or organ-systems include, with some inevitable overlap with tissues: the skeleton, which may be compared with houses, roads, harbors and the civil engineers, architects and workers responsible for them; the skin and other protective systems with the military and penal bodies; muscles with farmer and labor groups; the circulatory system with all sorts of carriers and their producers and operators, the liver with grain elevators, merchandizing concerns, perhaps banking institutions, the reproductive system with the family and some aspects of other formative social groups and agencies, including school and church; endocrines with mechanical, electrical and other engineers, tool and machine manufacturers, perhaps publishers and advertising agencies, the nervous system with governmental bodies, aspects of schools and publishers, radio, motion picture and theatrical organizations; limbs and other structural regions of the body with cities and villages, etc Certain body functions even are represented by concretized social organs—as memory and libraries, metabolism and banking, trading and manufacturing organizations [5]

[5] One student of communication insists that the main functions of this are mutual approval and support. Homologous needs of the cells in a metazoan would be served by all the agencies of org integration, not only the one of transmission.

I am fully aware of the limitations of such pairings, indeed were the homologies too simple it would throw doubt on the value of the whole procedure. At least as great difficulties attend any similar attempt to homologize cellular and organismic components—as the nucleus with the reproductive system, cyclosis and diffusion with the circulation, the cell membrane with the skin, the genes and enzymes with the endocrines. The real focus of interest in the epiorganism, however, is not now in its units of various levels, but in the mechanisms which integrate them into an org

The mechanical and spatial factors may be passed over—though physical crowding has molded our skyscrapers and our slums, and brute force still too often decides local action and national destiny. Transportative coordination has obviously undergone steady evolution in speed and efficiency and so made possible ever closer integration over ever greater areas The sequence from horse or canoe to airplane and ocean clipper parallels and is in large part responsible for the evolution from nomad or frontier bands to world empires Further, as the many-celled organism has stabilized and enriched the milieu of its cells and introduced new agents to strengthen transportative coordination, so the epiorganism makes available to its units a steady supply of food, water, heat, light—compare the regulated environment of the city dweller with that of a really self-dependent woodsman—and has introduced money and credit as new mechanisms for transportative integration

Transmissive coordination in the epiorganism, communication, depends on the spread of ideas or symbols which are hierarchically homologous with nerve impulses. In poorly integrated forms the speed and distance of spread are low, mostly by conversation within earshot or the call to a distant person. Improved epiorgans have increased the rate and range through telephone, telegraph and radio, and, correspondingly, the strength of integration of the org [6] Printed or written symbols—in newspapers, books, journals, letters—are somewhat anomalous in that they are transported as materials yet transmit ideas. Oddly, an exactly similar overlap occurs in the more elaborate organisms in which transmission is partly achieved by the liberation and diffusion of exciting chemicals —the neurohumeral substances

But though the facilities for transmission, the nerve fibres of society, are indeed highly perfected, the impulses which travel along them leave much to be desired The social nerve impulses, the symbols of language, when they achieve more of the all-or-none character of the organismic ones will convey less ambiguous meanings and lead to a more definitive stimulation and action of units And a coordinating central nervous system hardly exists—true centralization of control is just coming into existence and a suprasegmental epicortex is a negligible rudiment In terms of transmissive coordination and adaptive amplification, our best societies today are at the nerve-net stage of the jelly-fish or perhaps entering the gangliomated central-cord stage of the flat worm A less pleasant comparison is invited when we take into consideration the high degree of specialization of other epiorgans, the efficient effectors and nerve fibres, for then our present society resembles a man of well-developed body and undeveloped mind, a powerful imbecile Still some neuroid epiorgans do exist and help canalize and center transmission Besides publishers, writers,

[6] My consultant points out that increased communication breaks down the local community differences and loyalties in favor of large-scale stereotypes This is, of course, true for spatial groups, but very partially so for functional ones Publications, meetings, etc, certainly help to reinforce the cohesion of professional, religious, industrial and other bodies.

performers and their vehicles, there exist the schools with their teachers and the churches with their ecclesiastics, the courts and other legal institutions and practitioners, the various agencies and personnel of government, the advertisers and propagandists And underlying the activity of all these agencies are the crystallized or more amorphous behavior patterns, the laws and mores, laid down and set in the course of evolution, as are the fixed reflex patterns of the vertebrate segmental nervous system.

GRADIENTS

But perhaps the most important coordinating mechanism in present day epiorganisms is the gradient, which acts in surprising detail like that in organisms To be sure, the quantitative scale is not in such things as metabolic rate or mechanical power, as in the organism; nor are the units in a constant spatial sequence Also, the mechanism of gradient operation is surely different in the two cases—though we know less about that in the multicellular body than about that in the social group. But the relation of dominance and subordination, of ascending control as a powerful agent in enforcing org unity, and determination of the differentiation of units for special org functions by this agent, are closely homologous in the organism and epiorganism.

The primitive example of gradient action is the family. The parents, usually the father, are dominant and the children are molded by them Even here, very complex relationships between all the units—older and younger children, males and females, brighter or healthier and less favored—are known in detail and their influence on the individual's development is analyzed. With maturation of the subordinate units, the gradient breaks down and the small org largely or completely disintegrates, or else a new dominance is established by another unit, as when the oldest son assumes the father role Entirely similar gradient relations exist in other less knit groups—the neighborhood group, especially children's play groups or gangs, social cliques and clubs—and depend on leadership by certain individuals. These are the sociologist's "primary" groups.

But far more elaborate gradients underlie many epiorgans and parts and are, indeed, the normal basis of the integration of most social institutions Consider an army, a university, a labor union, a banking house, a department store, the Masonic Order, the National Government, the British peerage. In each case there is a clear hierarchy with successive levels of dominance and subordination, from general or president or director or king to private or clerk or common citizen If the head units of such an org be lost, the next ones in the gradient commonly assume control and the missing parts are regenerated; if the most subordinate units are lost and not immediately replaceable from outside, those left at the low end of the gradient are "dedifferentiated" to take over the missing functions and regeneration is achieved The fate of any single person, as of a particular flat worm cell, is influenced by his position in the gradient On a still larger scale, especially in societies of old and stable tradition, a gradient of social classes and castes runs through the complete epiorganism, as the main antero-posterior one of the flat worm overshadows the many minor ones in organs and tissues which correspond to those in family or army. (See footnote 2, regarding the multiple forces acting on the cell, for comparison with the obviously multiple, and more or less conflicting, loyalties which act upon the social individual.)

The most important aspect of organism gradients is their ability to help determine morphogenesis, to direct the development of the initially totipotent cell

into one or another path of differentiation and specialization, and the same is true for the epiorganism gradients. Human units are also totipotential (except for rare pathological variants with severe mental or physical handicap) and differentiate in relation to their epiorganism. This, of course, is *not* to say that all men are created equal, that great mirage of primitive democracy, nor that any man could become an exceptionally good composer, marathon runner, or chess player How effectively the unit performs its function depends largely on its inherited qualities; what function it performs, largely on its gradient and other org relations. Whether a child learns to speak English or Arabic is almost completely determined by the org of which it is a unit; the skill with which it uses that language, largely on its native talents

All levels of fixity by birth and flexibility by situation exist, both in the determination of cells and of persons The earlier in the history of the individual certain differentiations are established, the more profoundly different and unalterable the types they produce. Only for a brief period may any one cell differentiate either as liver or intestine; throughout life one sort of connective tissue cell can change into another. A child born into one caste is already restricted permanently to certain limited social roles; the same limitations are set by sex, different in matriarchal than in patriarchal societies; the structures of language and mores are set by family and similar groups in the early years; the further circumscriptions of general schooling, occupational training, etc , follow later and are progressively less irrevocable in their consequences. With longer functioning in any one role, however, redifferentiation becomes more difficult. An established doctor or merchant or machinist is unlikely to take up another's occupation.

Despite these factors making for fixity, the units can still respond to changed gradient conditions The salesman or chemist or bookkeeper or teacher can take on the duties of administrator and gradually change his competence, his viewpoint, his interests, even his habits of life and dress under the quiet pressure of his new duties. Conversely, the adult, and particularly the child, excluded from normal gradient determination by relative lack of family attention and looseness of other group contacts, tends to develop non-adaptively (The "anomie" of French sociologists) Groups of such hoodlum children become epiorganism zooids, not subject to the ordinary social controls and causing conflict in the parent org. It is sound biology, as well as good social sentiment, to "clean up the breeding spots of vice"; and the method used when permitted by the wise settlement and social worker for doing this, strengthening the healthy organismic ties with acceptable play and occupational interests, is also sound

Other epiorganism zooids form and maintain themselves When spatially isolated, as in colonization, the daughter epiorganism may peacably go its own way and reduplicate more or less closely its parents Or separation may be convulsive, by revolution, or incomplete, leaving a loose empire. Other zooids, spatially less isolated, may form on a larger scale than the hoodlum gang and the resulting major schisms lead to stress, usurpation, revolt and civil war It is, in fact, in the relative feebleness of major gradients compared to the many lesser ones and in the poor integration of the org relative to the high differentiation of its units that the great crises of our society are rooted.

For one thing, the org forces which place units in the gradients, which select persons for leadership or subordinate positions, operate very poorly. Pearl has insisted that leadership is unique to mammalian groups, but the evidence of

Emerson refutes this for social insects. Not only is the queen the head of the colony gradient, but in sub-groups some one worker may persistently lead its fellows, largely, it is true, by physiological rather than psychological dominance. Conversely, even in vertebrates, the same goose does not always fly at the wedge point nor the same deer stand sentry for the herd Yet is it true that leadership is more striking in mammals and man, and it becomes more a matter of superior mental abilities rather than one of greater physical strength as the group evolves But it also becomes closely tied up with social as well as chromosome inheritance

In one important point the body cell is not always hierarchically homologous with the social individual but sometimes rather with the single family tree. The most differentiated cells—brain, muscle, sense receptors—are coeval with the organism; each is formed in the embryo and persists as an individual throughout the life of the whole Other cells—blood, skin, connective tissue—are more ephemeral, and successive units of like kind and from common stock give continuity to the tissue. In the epiorganism all units are short-lived relative to the whole, and even the most specialized functions are served by a succession of individuals. Often these come from a common stock or single family—indeed, the family tradition of doctors, craftsmen, even jailers, is still strong to-day though no longer supported by the secret knowledge passed on ceremonially from father to son And, of course, the families composing the aristocracy, with or without formal titles of nobility, change very slowly except in new or metamorphosing epiorganisms [7]

Units are, therefore, to a greater or lesser extent born into certain gradient positions In so far as membership in a particular family insures certain capacities, inherited via chromosomes and early training, this is as sound as having the same epithelial cell stock continue to provide the epidermis In so far as nature and nurture of the individual are independent of family membership, succession based upon descent destroys the gradient of ability and leadership. Of course, some intermediate condition actually exists The children of the banker and those of his cobbler will show, on the average, little consistent difference in endowment, a significant one in training (though many social case histories leave much doubt that the "privileged" child has the best of it), and a still greater one in final gradient level; but in individual cases the shoemaker's son will dominate the banker's I doubt that anything would more effectively advance our epiorganisms of to-day than improved placing of units in gradients at their proper quantitative level This will be ever more

[7] I omit consideration of the problem of aging in the epiorganism, though here also interesting parallels with the organism can be drawn. An old org is composed of units of a greater average age, and just as some cells in advanced metazoans have come to endure as units for a relatively long time, so also is longevity of the individual in the epiorganism increasing Life expectancy at birth has almost tripled during the two millennia from the Roman Empire to that of Britain Old men, as old cells, are less hospitable to the new and changing, and the org they come to constitute is ever slower with innovation. Conversely, with long lived units there is a correspondingly prolonged period of immaturity The nerve cells of the human brain continue to multiply for a few years after birth and man, the longest lived mammal, has by far the longest period of formative immaturity. The long childhood and youth, in turn, have favored strong family relationships and so the development of society It is hardly surprising that social growth, for example the period of formal schooling, is also becoming prolonged, and, as our society endures, that ever older men are found in the positions of dominance.

A further point that will not be pursued is that the epiorganism is based upon sexual reproduction, through the family, just as the multicellular organism is based upon the asexual reproduction of cells Mitosis is thus seen again as a precursor and partial homologue of sexual reproduction.

possible as measures of individual capacities and achievements are developed and applied. Present difficulties would diminish further if the great discrepancies which exist in the social rewards for function performed at different levels were lessened. This raises the question of the intensity of the forces of integration within an org, seen in a society in terms of power and freedom.

Power and integration increase together. The well-integrated animorg captures more substance and energy from its surroundings than does a poorly integrated one; and the rise in physical power resources tapped by present epiorganisms—coal, gas, oil, water, and possibly soon atomic energy—has been prodigious Greater energy supplies and more specialized and organized epitissues and organs in turn greatly augment the intensity of intraorg forces and the power of the society over its members Transport of materials and communication of ideas, changing from camel-back to air-express and from vagrant gossip to national radio hook-up, make the difference between nomad, self-sufficient Arab bands — constituting an epiorganism hardly at the sponge stage of integration—and sessile, internally and externally interdependent English citizens, an epiorganism approaching the integration of a flat worm. In fact, these newer social structures are rapidly bringing into existence still more integrated orgs, the totalitarian states, with still greater power over their units—by propaganda and censorship—and the discrepancy between magnitude of power and control of its use by poorly selected dominant units is becoming intolerable

Freedom

The picture is commonly painted of ever more ant-like human societies with the individual reduced to a helpless slave of the group, lacking initiative, swathed in restrictions and altogether a sorry case That social control will increase, I am certain; but that an abject citizenry *must* result, I can not agree. I have already pointed out that freedom implies conformity rather than license. The org must modify the action of its units, but restrictions are balanced by new opportunities. As integration evolves, certain types of behavior are forbidden but others are created or made possible. If we, in present society, are not "free" to go naked in the summer, neither were the Indians "free" to turn on steam heat in the winter We are not free to use the table manners of Henry VIII, nor was he to use a fork We must learn to read and write, the peasant of yesterday had not this privilege We may not kill, but radio, movies, books, even food packages with mystery serials, help us sublimate our aggressions. It is rather like wandering on through the countryside—each fork of the road calls for renunciation of one alternative but leads to two new ones

And, note, of the controls and checks to which we submit we are mostly quite unconscious We are molded by the epiorganism and run free before its forces Indeed, we gladly conform to the great majority which we do recognize, for they operate through tradition rather than law and we accept that tradition Do we go without clothes or eat with our fingers in the sanctuary of our own homes? Our women do not feel thwarted and unsuccessful because they are not expected to compete for money and prominence; while men, in our society, feel inferior when not supporting their families. But in matriarchal groups the reverse roles are as unquestioningly accepted Men born into a caste, apprenticed into a guild, trained in a craft are proud to do their jobs well and do not feel forlorn at the impossibility of becoming king. The relative fluidity of our own early culture and the "freedom" that American youth has to "rise to the top" has certainly produced little contentment—

European visitors and local psychiatrists are impressed with the restless striving which is almost a national psychosis.

No, it is possible for men to be part of a highly integrated society and yet feel, as individuals, more free, actually to have more avenues open for satisfying self-expression, than when they are epiorganisms of their own, like single-celled organisms. Which of us would exchange our present state for the privilege of roaming the woods naked and unarmed, without language or fire? But this will be true only as the society evolves along the lines of gradient and other control and is solidly based on the cooperation of its members. A set of regulations imposed by a few usurpers of power, dictatorship of the current stamp, sits ill and is not long tolerated. The control of the org by its units can not be arbitrarily abolished; the head is the dominant end of the gradient but not independent of it. Neither prohibition nor clean sidewalks and parks can be forced upon the average American citizen of to-day. But mores change more rapidly than they used to, under the impact of mass propaganda, and social attitudes can be manipulated.

Another word is needed on the matter of conflict between individual and social interests, of free or fettered behavior. We have seen that cooperation of units in an org has survival value at cell and organism levels; it has regularly been preserved in evolutionary change. This is no less true at the epiorganism level—cooperative groups, from bands of prehistoric man on, have survived or overcome their more factional contemporaries. And the unit mainly performs his altruistic actions not by external but by internal compulsion, because of loyalties that are part of himself rather than of laws imposed upon him. True, the growth of personal affections and loyalties and of conscience (or, in Freud's terminology, part of the ego and the super-ego) is conditioned by the group—but so is his very ability to think at the symbolic level of language. And some altruism is certainly very old in vertebrate life—many animal, as well as human, mothers will defend their young with their own lives, and this self-sacrifice may extend between other members of the family group. But a carry-over to larger org groups occurs only under such org influences for they demand greater abstraction. Yet even dogs, under the influence of human groups, perform many acts which show every sign of abstract loyalty; and football heroes play on despite the pain of broken ribs for the glory of old Eli, abolitionists risked much in running the "underground railway" from an abstract loyalty to humanity; loyalties are very real to vocational, religious, local and other groups; and when a country is actually attacked few indeed of its members are not genuinely willing to fight and, if need be, die. In fact, however "low" the "morals" of the state, seen in terms of the self-interest of some controlling man or group, the mass of people give it loyalty because of an appeal to their humanitarianism rather than to their selfish interests.

IS OURS THE "AGE OF INSECTS"?

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In popular treatises dealing with organic evolution and in accounts of the geological history of life in our planet, it is customary to denote certain periods by reference to dominant groups of animals or plants Thus, in relation to animals, the Devonian becomes the "Age of Fishes;" the Mesozoic, the "Age of Reptiles," and the Tertiary, the "Age of Mammals." Similarly, botanists have other catch-phrases, but in the true spirit of self-admiration we are all generally agreed that the Quaternary is the "Age of Man" In this rather inexact terminology these periods represent the rise of the several types of animals to widespread abundance, extensive speciation and world dominance As the phenomena are successive, each type has later been replaced, or will be in the future if organic evolution proceeds as we know it has in the past.

Even in our own case, reference to the Holy Scriptures will reveal the fact that the fall of man has already transpired and that according to the diligent researches of Bishop Ussher this is exactly 5,933 years past at the present moment Aware of this incident in the Garden of Eden, entomologists have proclaimed recently that we are now really in the "Age of Insects," and that man, already a back-number, must stage a fight for his life with the insects This has demanded the stationing of economic entomologists in the trenches or in air squadrons to shower the enemy with poison dust and thus make the world safe for agriculture and permit unrestrained multiplication within the human species.

There is, of course, a modicum of truth in all this. From a purely anthropocentric view-point it is perfectly logical to regard the menacing spread and increase of a few highly destructive insects as an "Age of Insects," and the latter would mean just another monkey wrench in the machinery of human progress.

However, it is far from my intention to deal with our present world, but to revert a few centuries to the Age of Man, the animal, when he was still unhampered by the newer age of machinery or gadgetry that has served him lately to muddle the destiny of the whole living world, including his own precious human brethren. From the standpoint of the biologist, who believes, or at least ought to believe, that all organisms have their place under the sun, it is still an interesting though more academic question to ascertain whether insects are still in their ascendency

How may we recognize the heyday of the insects or of any other group of animals? For an answer to this question we must rely upon an examination of their characteristics at the present time in comparison with the meager information so far accumulated concerning their past, with perhaps some dubious predictions as to what Nature may hold in store for them in the future.

There appear to be several partially independent lines of approach that involve matters which we know have been concerned in the rise of groups like the reptiles and mammals These two are to be mentioned particularly, since we have unusually full information relating to their actual evolutionary history. We shall have to distinguish three phases which are successive and continuous in every respect In the first, the group of animals is still on the upgrade in the struggle for existence and augmenting

the pressure that it exerts upon the living environment, in the second it has attained the peak or heyday of its development, in the third it has passed its prime to enter a period of senescence or decadence, mainly contingent upon the rise of competing groups Such a sequence seems to be inevitable among organisms and it has been repeated many times In which phase a group falls may not readily be stated in dogmatic terms except in cases where we have historical knowledge that includes all three stages. For some groups this is available, notably for the reptiles, brachiopods, xiphosurans and many others, but if the third stage can not be demonstrated we must rely upon more questionable evidence to distinguish between an increasing or a static condition of dominance We are obviously in this dilemma concerning the insects, for entomologists are not wont to admit that these animals form a decadent group, although it has been made clear that the more primitive orders have long ago declined in competition with the more highly specialized ones, namely, those which undergo a complete metamorphosis during ontogeny The insects as a whole are nevertheless universally regarded as in the prime of their evolutionary ascendency, forming, as they do, the dominant series of invertebrate animals On this account our present era has been termed the "Age of Insects," quite aside from their economic status in relation to human activities

It is with this statement that I feel obliged to differ at the present time, as it does not appear to be justified in the light of present knowledge

The relevant sources of information may be grouped roughly as follows in several categories, each in a sequence with reference to time Abundance; extension or reduction of range Diversity; speciation; specialization in structure, development and behavior. Size of individuals

Contributory factors, such as fecundity, food-supply and susceptibility to parasites, are not easily evaluated in dealing with extinct faunas Furthermore, we can not disregard the predestined orthogenetic tendencies among animals that are a characteristic of evolutionary progress, even though these are in disrepute among many genetical biologists [1]

With regard to these sources of information the insects may be examined with some degree of exactness during at least a part of their history There are naturally wide and serious gaps in the sequence, but I believe that we now have in hand sufficient data to warrant a rather definite statement that insects as a whole have reached the peak of their development and that their period of decadence has already set in As usual with systems involving man, nothing in the future is predictable on the basis of analogy, even though his influence should pass out of the picture, for the expectancy of all other forms of life in a future

[1] This statement may be questioned as not universally true For example, the late Professor E M East recognized the difficulty of reconciling the phenomena of determinate evolution as accepted by paleontologists with the genetic interpretations of gene mutations and dominance in experimental animals and plants. One of his last publications contains a consideration of defective and non defective mutations, together with a statement of these difficulties and the bearing of the slight, non-defective type of mutations upon evolutionary theory East's discussion is not developed specifically in relation to orthogenesis, but the possibility of its application thereto is obvious Attention is called to this paper partly in justification of my own remarks, but more particularly as its title "Genetic Reactions in Nicotiana" (*Genetics*, 20 443–451, 1935, later summarized in part in *The American Naturalist*, 70 143–158, 1936) gives no hint of the broad scope of its contents. These deserve wider notice and consideration by biologists, as they may serve to bring together such divergent views on evolution and speciation as those voiced recently by Reusch (*Biological Reviews*, 14· 180–222, 1939) and Muller (*ibid.*, 70 261–289), neither of whom refers to East's papers.

world has already been irrevocably altered by our own brief and disturbing presence It is clear therefore that it is useless to peer into the future of any series of animals.

The basis of all knowledge of the past history of animals must rest on the recovery of their fossil remains, and it is well-nigh impossible to reach any statistically valid conclusions concerning abundance at any particular time Fossilization depends upon the chance combination of physical, chemical and ecological factors, and recovery of such material depends likewise clearly on chance Moreover, insects are small, less readily recoverable than larger animals and not so easily reconstructed from fragments. There is, however, very fortunately a happy combination of circumstances which resulted in the preservation of innumerable Tertiary insects in Baltic amber that permits a most concise study of the insect fauna of the lower Oligocene It is from these amber insects that I wish to draw much of the material data now to be presented Experiments conducted by the writer (*American Naturalist*, 67 · 385–406, 1933) enable us to indicate what part of an insect fauna we may expect to trap in the sticky resin exuding from trees, and this is the very way that insects were caught in the Oligocene resin which has now hardened into the amber within which they are permanently preserved From a census of insects caught in a forest by means of tanglefoot we find that there is a selection of smaller species, as the larger ones are better able to drag themselves loose, consequently, we can discount the consistently small size of the preserved amber insects. In the paper just referred to I have dealt at far greater length than is here feasible with the comparative abundance of insects in general in amber and in the modern forest, reaching the conclusion that they were certainly no less numerous in the amber forest. It is evident that there is a difference in the numerical representation of several orders in the two faunas, and that what we may definitely consider to be the more primitive ones were proportionately more abundant in the amber fauna than in the recent one This is true of the Coleoptera and Diptera, both modern orders with complete metamorphosis The former are undoubtedly an older, more generalized group than the Diptera, which are morphologically the most specialized of all insects They have become much more numerous, while Coleoptera have dwindled greatly since the early Tertiary Two other orders, Lepidoptera and Hemiptera, show a notable increase, and three, Thysanura, Collembola and Trichoptera, have suffered a conspicuous loss in numbers during the same period [2] It will be noted that the present-day preponderance of holometabolous insects that has replaced the very abundant Hemimetabola of the late Paleozoic served to change entirely the complexion of the insect world during the Mesozoic This occurred undoubtedly during the earlier part of the Mesozoic Direct evidence on this point is not so complete as might be desired due to a great dearth of known cretaceous insects It is incontrovertible, however, that many of the more specialized types of higher insects were evolved and greatly diversified long before the dawn of Tertiary times.

A continuation of this trend during the Tertiary has resulted not only in a greater prevalence of forms with complete metamorphosis, but in a selective change among these orders An example of this is an increase of Lepidoptera coincident with a diminution of their obvious precursors, the Trichoptera. Thus, although the status of individual orders shows notable and quite consistent changes, it conforms readily with

[2] The supporting data for these statements are included in my earlier paper cited above

what we should expect from the progressive differentiation and specialization of families and smaller taxonomic units. Aside from these changes there is no reason to believe that insects have increased in abundance during the late Tertiary or Quaternary.

As to extension or reduction of range during this period it is very difficult to secure positive data, as the amber and other Tertiary insect remains represent only isolated faunas. Nevertheless, there are cases like the occurrence of tsetse-flies, now restricted to Africa, in the Miocene of North America and the appearance in Baltic amber of genera of ants now persisting only in parts of the Austromalayan region. To these might be added many other examples of similar nature, but individually more open to question since the present distribution of many of the less conspicuous groups of insects is far from completely known. In the aggregate, however, there is much evidence in support of the belief that certain types now still numerous in restricted areas enjoyed far wider range during the Tertiary.

With relation to diversity and speciation, the amber insects supply us with more extensive and concise information These have been studied with care in only a few groups, as it is a slow and tedious process to examine them minutely, but the amber fossils are so perfect that their taxonomic relationships may be determined almost as completely as those of living species I shall refer to only two groups which are personally familiar to me in both the living and amber faunas.

One of these is the family Phoridae, highly specialized Diptera that form a compact group, quite sharply distinguished from their relatives by good morphological characters There are well over 1,000 described living species distributed in about 100 genera, one of which (Megaselia) includes fully half the known species. The amber fauna is known to contain at least thirteen species distributed in ten genera, but only two species belong to Megaselia, and four of the genera are now extinct so far as our knowledge extends.[3] As might be expected, the four Oligocene genera are more primitive in that they are to some extent intermediate between the three living subfamilies, but each shows also some highly specialized character that is either unique or repeated only in some aberrant living genus There are among the amber species also highly differentiated forms obviously ancestral to living forms. One of these, Protoplatyphora, is very similar to the recent Aenigmatias, but clearly more generalized. The living genus is remarkable in having greatly degenerate wingless females living only in ant-nests. Only males are known from amber, but these are abundant and there seems to be no escape from the conclusion that these flies were not only myrmecophilous at that time, but that apterous females had put in their appearance and being subterranean in habits did not find their way into the amber. The living species occur with Formica, which was a dominant genus of ants during the Oligocene of Europe just as it is in the recent holarctic fauna That these ants were as perfectly attuned to their environment then as now is attested by the persistence of the most abundant ant of the Baltic amber, *Formica flori*, to the present day with such very minor changes that its living representatives (*Formica fusca*) are scarcely distinguishable as a separate species. Moreover, *fusca* is still the dominant member of its genus in the holarctic region, although a great sufferer from various parasitic enemies, to which it has fallen prey during its long exposure to such dangers. With the

[3] These are considered in detail in my recent "Fossil Phoridæ in Baltic Amber"; *Bull. Mus. Comp Zool.*, Harvard, Vol 85, pp. 413–436, 7 figs (1939).

ants as with the Phoridae just mentioned, the amber fauna shows also the presence of species with some of the highly specialized developments of modern ants Thus, as the late Professor Wheeler has pointed out in his study of the amber ants, a dimorphic worker caste was already present in several genera, and in one genus, Erebomyrma, it even appears probable that the large, soldier form of worker had been developed and subsequently lost before the Oligocene

Great specificity in food-habits is an outstanding characteristic of living insects equally prevalent among vegetarian, predatory and parasitic types It can not be doubted that the origin of many of these specialized dietaries must be traced back to the lower Tertiary, since when we examine them in the light of distribution and taxonomy, it is clear that they have persisted over periods of time long enough to permit extensive speciation and great geographical movements Specificity of food relations involves the persistence of instincts, and for this reason we must admit that the phases of instinctive behavior here concerned are likewise of equally long standing [4]

It must be noted, however, that practically all herbaceous plants are quite generally believed to be of very recent geological origin, probably not more ancient than the Pliocene If this be true we are faced with apparently insurmountable difficulties in understanding the present extended geographical range of many genera and other taxonomic groups of higher plants Certainly, also, the food restrictions among certain groups of vegetarian insects speak for long associations between them and their food-plants For these reasons one is led to believe that the apparently late appearance of these herbaceous forms may be one of the vagaries of nature in her preservation of fossils, similar to many others that block the path of paleontological research

From almost every point of view the several groups of insects that develop as entomophagous parasites outrank the other members of their class in the extent of their specializations They are also very numerous and give evidence of being a recent product of insect evolution Consequently, it should be illuminating to look at these in the light of the Baltic amber fauna The largest series with habits of this sort is composed of a number of related families of Hymenoptera These parasitic Hymenoptera are abundant in the Baltic amber, and a considerable part of them have been studied [5]

If we expect to find these canny creatures represented by drab and dumbbell ancestors in the Oligocene, we are doomed to disappointment They are neither dowdy in appearance nor Victorian in manners, but are readily mistaken for preview models of 1940 In diversity, speciation and structural specialization they are in no way inferior to the living members of their respective families, and a number of the most bizarre developments in recent genera are already known to have their counterparts in the Baltic amber fauna

Here, as with the Phoridae and ants mentioned previously, the amber fauna is primitive in that it includes one extinct family, Pelecinopteridae, more or less intermediate between two living ones and because several of the more primitive families are better represented there than in the living fauna

[4] I have recently summarized some of the matters pertinent to the persistence of instincts among insects in "Food, Drink and Evolution," *Science*, 90 145–149, 1939

[5] The writer has published a general account of these as "The Parasitic Hymenoptera of the Baltic Amber, Part 1" (Bernstein Forschungen, Heft 3, pp 4–179, 1933) This and further unpublished parts have supplied the data on which the following paragraphs are based

When we examine the genera more in detail, however, the abundance of highly modified types is surprising. In several families there are living genera that have the body greatly flattened much after the fashion of many insects that live beneath the bark of logs. Such forms had quite reached their present remarkable form in the Oligocene, as the amber contains the precursors of these strange types in at least three independent instances.[6]

The females of many of these parasitic Hymenoptera are provided with a greatly lengthened stylet-like ovipositor which enables them to insert their minute eggs into the host, often through intervening plant tissue. In the ichneumon-flies the ovipositor is not retractile and must be trailed about like a miniature strand of tenuous spaghetti, but in other forms it may be withdrawn within the body like a sting and concealed when not in action. In some Scelionidae there appears at the base of the abdomen a dorsal protuberance which becomes so greatly elongated in several genera that it protrudes as a hollow horn, curving upward over the thorax to form a scabbard into which the basal portion of the ovipositor is withdrawn. This handy little affair permits the development of an ovipositor much longer than the abdomen, yet completely retractile. Contrary to expectations, this structure is not new, but has its counterpart likewise in the scelionid fauna of the amber. Many similar examples relating to other structures might be cited.

There remains the question of individual size. This might seem quite inconsequential were it not for the fact that the rise of certain other groups of animals has been so definitely associated with an increase in bulk of the individual organisms, leading often to giantism with its implications of metabolic and ecological unbalance. The exact nature of such resulting maladjustments is frequently open to question, but the fact remains. Among insects the restriction of stature is usually admitted to depend upon physical phenomena attending the periodic molting of the external skeleton during growth and upon a spatial limitation of the respiratory function inherent in the structure of the insect's tracheal system. We do know, however, that insects much larger than any now living once existed and that their average size at all times has been far below any limit that might be fixed by physiological requirements. Nevertheless, it can not be said that there has been any consistent change of size in comparable groups since the earliest known Paleozoic forms of insect life appeared.[7] As we have already noted, one can detect no changes during the course of the Tertiary, and here we have a very large assemblage of known forms on which to base our conclusions.

It seems reasonable, therefore, to discount the dire prediction that insects are at the present time threatening to engulf the more modestly expanded groups of animals that now share the world with them.

The more immediate practical menace of insects to agriculture is of course another story. Here we can only apply to ourselves the threadbare allegations of propagandists that clog the short-wave radio: "You are the source of the trouble and you must bear the consequences."

[6] These are Platyscelio and Platytelenomus, members of the subfamilies Scelioninae and Telenominae, respectively, in the family Scelionidae and Palaeobethylus in the family Bethylidae. The latter is abundant in the amber and is represented by three species.

[7] A detailed consideration of the trend of insect stature throughout the geological history of the group is included in Professor F. M. Carpenter's "A Review of Our Present Knowledge of the Geological History of the Insects," *Psyche*, 37: 15–34, 1931.

THE TULAROSA MALPAIS

By Professor LEE R DICE

DIRECTOR OF LABORATORY OF VERTEBRATE GENETICS, UNIVERSITY OF MICHIGAN

In the Tularosa Basin of southern New Mexico lies a large bed of black lava, the Tularosa Malpais The local name "Malpais" (pronounced mal′-pī) is evidently a modification of the Spanish words *mal pais,* meaning a bad place The Malpais truly is a bad place for any one attempting to cross it with a horse, even to a man on foot, travel over the broken lava is extremely difficult Several automobile roads, however, have been built across the lava bed, by which it may now be crossed with ease For the tourist who may wish to visit the Malpais, accommodations can be obtained at Carrizozo or at other nearby towns

The time of extrusion of the lava making up the Tularosa Malpais could not have been more than a few thousand years ago at the most, for the lava rocks are still sharp and hard, with little evidence of the weathering which quickly dulls the sharp edges of exposed rocks

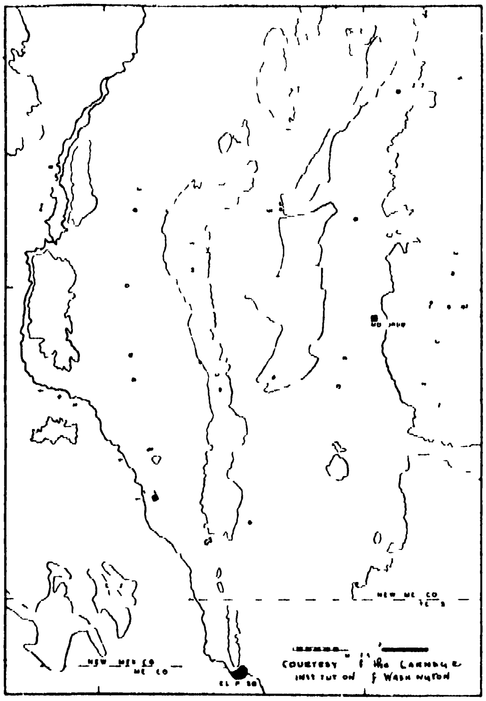
Just northwest of the fresh-looking lava of the Malpais is a smaller bed of much older lava, greatly weathered and almost obscured by the vegetation which covers it There have been, therefore, at least two periods of volcanic activity in the area

The volcanic cone from which at least part of the newer Malpais lava was extruded is still visible a few miles northwest of Carrizozo The cone, however, is low and flat, rising only about 200 feet above the general surface of the lava flow From this crater, and perhaps from others now concealed under the lava, the molten rock flowed southward down the gentle slope of the desert plain to a point about 13 miles southwest of Three Rivers The total length of the laval flow is about 44 miles At no place, however, is it wider than five and one half miles, and where hemmed in by hills it is much narrower Its total area is about 120 square miles

The lava must have been very hot liquid when it was poured out from the volcanic crater, for it has not piled up into large masses at any place, but has spread rather thinly over the plain At its edges, where it stopped in cooling, the lava rises usually about 10 to 20 feet above the desert sands, but in some places as much as 50 feet In the middle of its stream the lava must be thicker, especially where it has filled some ancient desert wash or other depression, and the small hills that lay in the path of the liquid lava were surrounded and left as islands which still rise above the sea of black rock

The surface of the lava is broken by great cracks and crevices, running in every direction Beneath the surface there are many large caverns, the roofs of some of which have collapsed and left great depressions filled with broken rock It is this broken surface of the lava sheet which makes it so difficult for large mammals to traverse it On the other hand, the abundance of caves and crevices makes the Malpais an ideal home for many kinds of small animals

No springs nor streams of water occur on the Malpais lava itself, although it is said that one can hear, deep down in some of the larger crevices, the gurgling of running water At the southern end of the Malpais, however, there occurs a large spring, called Malpais Spring, the water from which as it enters its large pool is clear and very cold This spring would be a godsend in the desert where it occurs if it were not for the fact that it, like



MAP OF SOUTHERN NEW MEXICO
SHOWING LOCATION OF THE TULAROSA MALPAIS

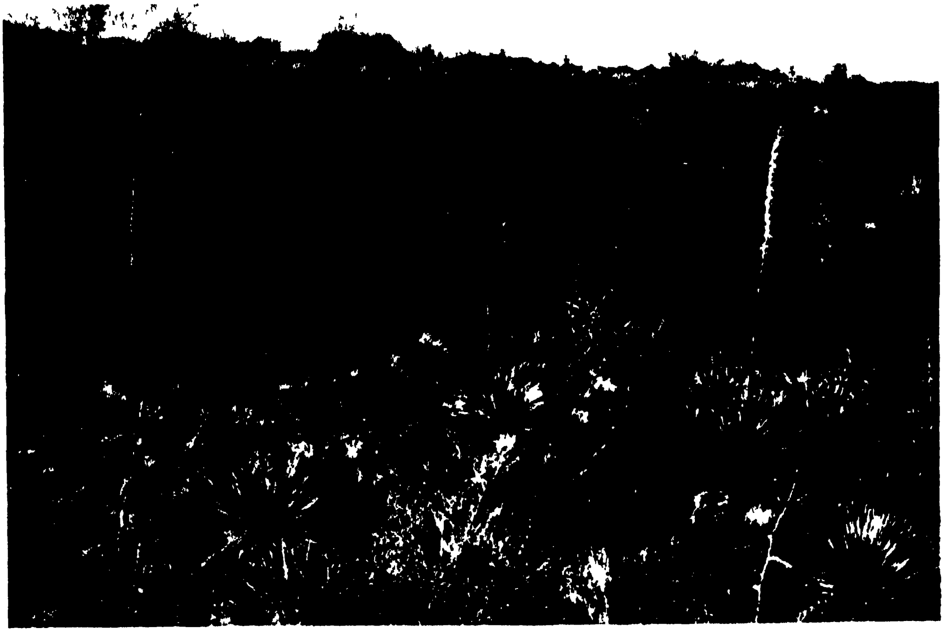
many other desert springs, is heavily saturated with alkali. In fact, the water of Malpais Spring is so heavily filled with common salt, gypsum, epsom salts and other minerals that a man suffering from thirst and drinking the water would likely die as quickly from the effects of the dissolved alkali as he would from lack of water.

In spite of the heavy saturation of various salts in the water of Malpais Spring, a large number of small fish live in the pool formed by the spring and in the small stream which flows from it for a few hundred feet before it is lost in the desert sands. These fish are all of one species, identified by Dr. Carl L. Hubbs as a peculiar member of the genus Cyprinodon. Closely related species of fish are widely distributed in isolated springs and streams in the southwestern deserts, all of which are presumed to have descended from marine forms, some relatives of which are still living in the Gulf of Mexico.

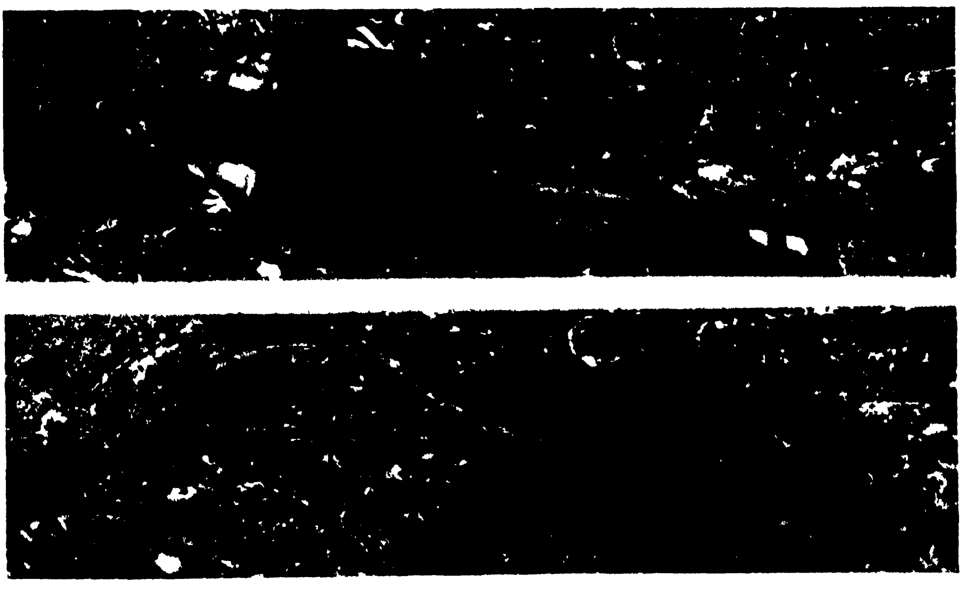
A scanty growth of vegetation occurs on the Malpais lava, in spite of the inhospitality of the habitat. From each crack in the rock where a tiny bit of soil has accumulated there protrudes a tuft of grass, a cactus or some other plant. It is remarkable that any plant can endure such a situation, for the rainfall is exceedingly scanty, and long periods in summer may pass with no precipitation at all. Moreover, there are drying winds and the heat of the summer sun is intense. The black lava rocks absorb so much heat that they become very hot, so hot in fact that one can not bear to hold one's hand on them. These black rocks retain heat so well that when they have become deeply heated, they are still distinctly warm to the touch in the morning after having radiated all night. Evidently any animal or plant which is able to live in such an environment must have special adaptations to enable it to endure drought and heat.

At its upper end, near Carrizozo, the Malpais is over 1,200 feet higher in elevation than its lower end at Malpais Spring. There is accordingly an important difference between the climate of the upper and the lower parts of the lava flow. At its lower end, the Malpais lies in the desert belt, and its characteristic plants are those of the desert, including mesquite, creosote bush and various kinds of cactus. At its upper end, the Malpais lies in an arid grassland area near the lower edge of the juniper-pinyon belt. Here grasses grow sparsely on the rocks, a few junipers occur, and there is an open growth of such plants as the sotol (Dasylirion), Spanish bayonet and a few types of cactus.

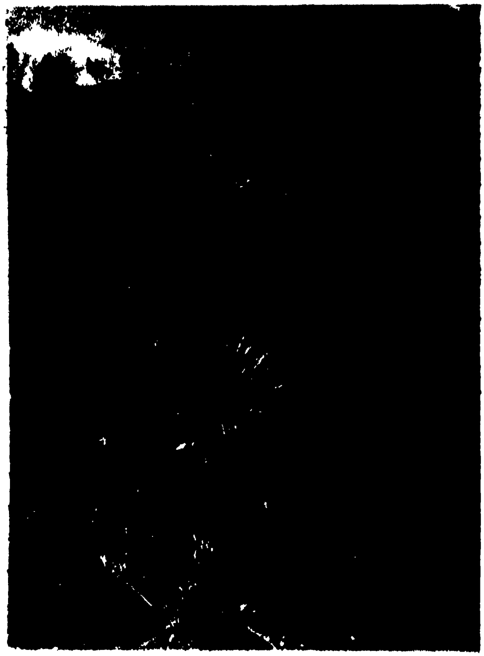
Small mammals living on the Malpais have very dark-colored coats, no less than six species showing a tendency toward dark pelage colors. Of these species, the rock pocket-mouse (*Perognathus inter-*

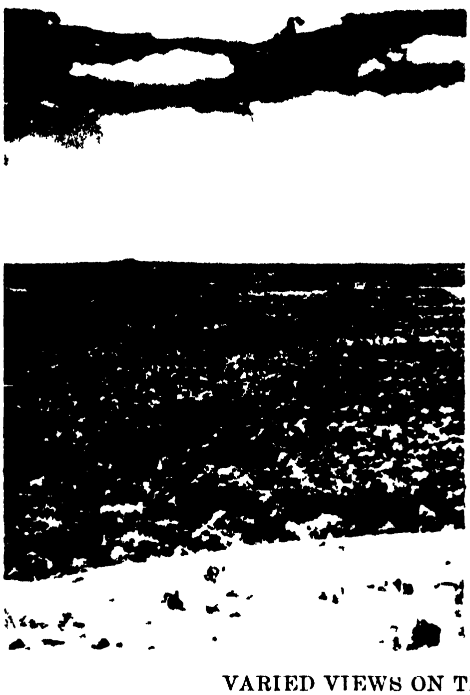


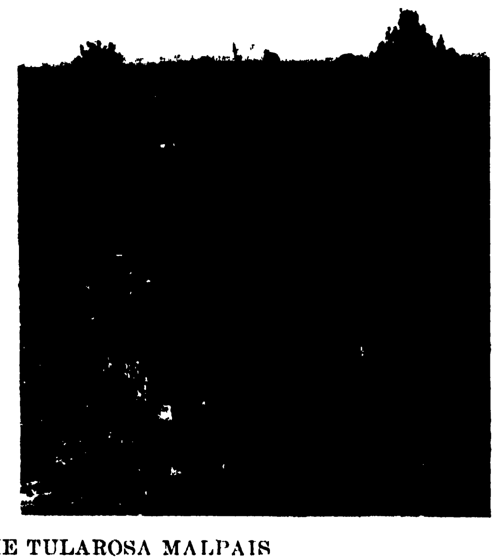
ABUNDANT CAVES AND CREVICES
IN WHICH SMALL MAMMALS MAY MAKE THEIR HOMES



JUNIPER MOUSE AND ROCK POCKET MOUSE IN CAPTIVITY
BELONGING TO A DARK COLORED RACE, AND RESTRICTED TO THE TULAROSA MALPAIS. SEEN HERE ON THE BLACK LAVA ROCKS OF THEIR HABITAT







VARIED VIEWS ON THE TULAROSA MALPAIS

UPPER LEFT: GRASSES AND OTHER PLANTS GROWING FROM TINY CRACKS IN THE ALMOST BARE ROCKS. UPPER RIGHT: SHARP LAVA ROCKS, SHOWING LITTLE TRACE OF WEATHERING. LOWER LEFT: MOLTEN ROCK FLOWING FROM THE SMALL CRATER IN THE DISTANCE AND FROM PERHAPS OTHER CRATERS NOW BURIED BENEATH THE LAVA, COVERED AN AREA OF OVER ONE HUNDRED SQUARE MILES. LOWER RIGHT: ON THE TULAROSA MALPAIS FIVE SPECIES OF RODENTS HAVE DEVELOPED DARK COLORED RACES, ALL OF WHICH ARE RESTRICTED TO THIS BED OF BLACK LAVA

medius), the rock-squirrel (*Citellus variegatus*), the juniper-mouse (*Peromyscus nasutus*), the white-throated woodrat (*Neotoma albigula*) and the Mexican woodrat (*Neotoma mexicana*) have developed dark-colored races. Some of the cactus-mice (*Peromyscus eremicus*) living on the lava are also dark in color, but many of them are no darker than individuals of the same species living on the pale-colored rocks of the adjacent mountains. Possibly the trend shown by the occurrence of some dark-colored cactus-mice on the Malpais will eventually result in the formation there of a dark-colored race of cactus-mouse also.

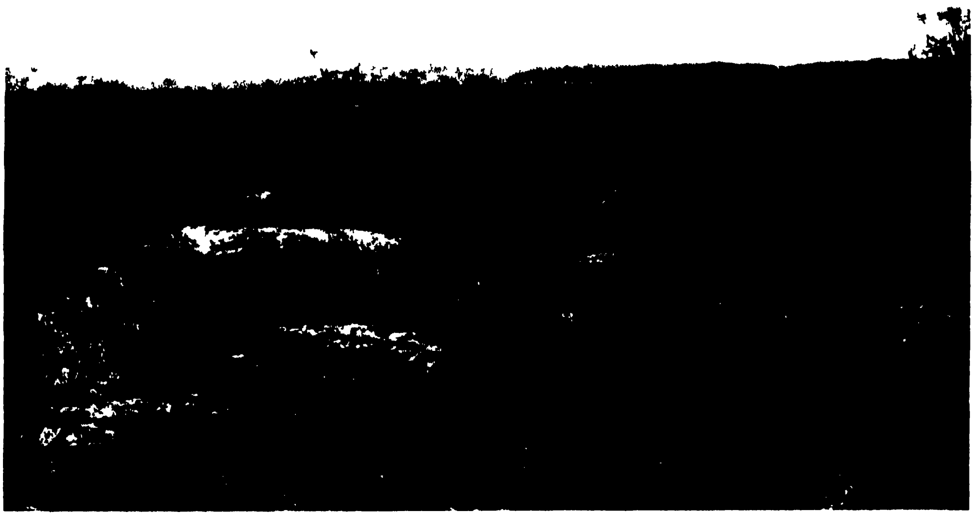
It is noteworthy that all the kinds of small Malpais mammals which are blackish in pelage color are those which are confined to rocky habitats. These are the species listed above. On the other hand, the species which occur both on the Malpais and on the surrounding pale-colored desert sands are of normal pale color, as they are in other parts of the southwestern arid regions. This applies to the cottontail rabbit, to the jackrabbit, to the coyote and to numerous other wide-ranging species. Evidently isolation has played a considerable part in the formation of the dark-colored races of small mammals which occur on this lava bed.

The reason that dark-colored races of small mammals occur on this and on other beds of black lava in the southwestern deserts is, however, not certainly known. The most reasonable explanation so far suggested is that pale-colored animals, being very conspicuous on black rocks, would therefore tend to be captured by predators, while the darker-colored individuals would tend to be preserved. Dark-colored races would thus in time be built up on dark-colored habitats by natural selection.

IRREGULAR EDGE OF THE MALPAIS

THE SMALL HILLS LYING IN THE PATH OF THE LAVA WERE SURROUNDED AND LEFT AS ISLANDS

It is an interesting fact that the Tularosa Malpais at its southern end lies only a few miles from the nearest edge



THE TULAROSA MALPAIS
AN EXTENSIVE BED OF VERY DARK COLORED LAVA ROCK IN SOUTHERN NEW MEXICO

of the White Sands, which lie in the same desert basin and at the same elevation. As is well known, on the White Sands there is found a nearly white pocket-mouse (*Perognathus apache gypsi*), which in color tends to match the white gypsum soil of its habitat. None of the pale-colored gypsum pocket-mice have ever been taken except on these pale-colored sands, just as none of the dark-colored Malpais mammals have even been taken elsewhere than on the black lava.

A considerable part of the White Sands are now in government ownership as a National Monument. Under the protection of the National Park Service these sands can be expected to retain their peculiar flora and fauna indefinitely, but unfortunately, no part of the Tularosa Malpais is under protection. Goats are now being pastured on at least part of the lava bed, and unless protection is given soon to the area it is likely that irremediable harm to the native plants and animals will result. In this rigorous desert habitat it takes years for many kinds of plants to grow to flowering age, but a herd of goats can in a single day destroy all the more delicate herbs and shrubs growing on a number of acres.

The Tularosa Malpais is unique in the number of dark-colored races of small mammals which inhabit it, its flora, although as yet little studied, shows many adaptations to extreme aridity, and to one with geological inclinations the lava bed itself is full of interest. Although suggestions have been made in the past that this lava bed be placed under the protection of the National Park Service, no formal plan is now under consideration. No serious objection to making the Malpais into a National Monument, however, is likely to be made by the local agricultural interests, for the forage available on the lava, even for goats, is almost negligible.

LIFE AND HABITS OF FIELD MICE

By Dr W J HAMILTON, JR.
DEPARTMENT OF ZOOLOGY, CORNELL UNIVERSITY

SHORT-TAILED, beady-eyed field mice (Microtus) are found in suitable waste lands throughout the temperate zones of the Northern Hemisphere Nearly one hundred species and their races occur in North America Although these microtines are of tremendous economic significance, the habits of most species are very little known Sadly enough, this is true of most of our small native mammals, for naturalists seem to delight in the rare or unusual and seldom direct their attention to the commonplace It is difficult to imagine why field mice have been so neglected Surely there is no lack of material for the investigator The communal habits and social life of these voles should intrigue the student of animal behavior; their extraordinary reproductive potential and cycles must eventually attract those interested in animal populations, while the pandemics which periodically beset these populations afford a fertile subject for the epidemiologist

HABITS OF FIELD MICE

Perhaps no other small mammal is so adaptable in its selection of a habitat in which to seek its food and rear its young Meadow mice swarm on the salt marshes, crowding to the very edge of the beach and taking refuge on floating jetsam when high tides flood their home The species occurs sparingly in dense woods in company with the shrews and big-eared deer mice, or inhabits the prairies of the Mid-west Field mice occur from sea-level to near timber line These mice are most at home in the lush meadows, where the damp earth gives rise to a dense vegetation of grasses and low succulent annuals, or in fields which support a canopy of dead grasses to shield them from the prying eyes of watchful hawks Even within the limits of the great metropolis, a vacant lot grown to weeds and grasses will support its quota of mice, if vagrant cats are not too numerous and efficient Lift a fallen sign board and you will see the little creatures running from their bulky grass nest to the shelter of the surrounding vegetation

Any one who has walked the fields and meadows has seen the little globular or slightly flattened nests of these ubiquitous creatures As the winter snows melt back, these shelters are left exposed and lie directly upon the surface, for it is a curious fact that mice build their nests on the surface of the ground during the winter months, and often tunnel below the ground to construct their shelters with the approach of warm weather The nests are prepared quickly, a few hours often sufficing, but withal, they are sturdily built The mouse gathers in its sharp teeth dried grasses near at hand, and weaves these into a compact ball, interlacing the stems and blades so firmly that the interior is quite waterproof Ordinarily each nest is occupied by a single animal From the soft interior, lined with finely shredded grass, one or more openings lead to the surface paths or to subterranean burrows The mice are cleanly little animals about their homes, and if the nest becomes soiled it is quickly deserted and a new one constructed

Part the dead matted grass and a new world is revealed Little paths, scarce the width of a garden hose, crisscross one another to form a labyrinth of mouse highways These little paths are made

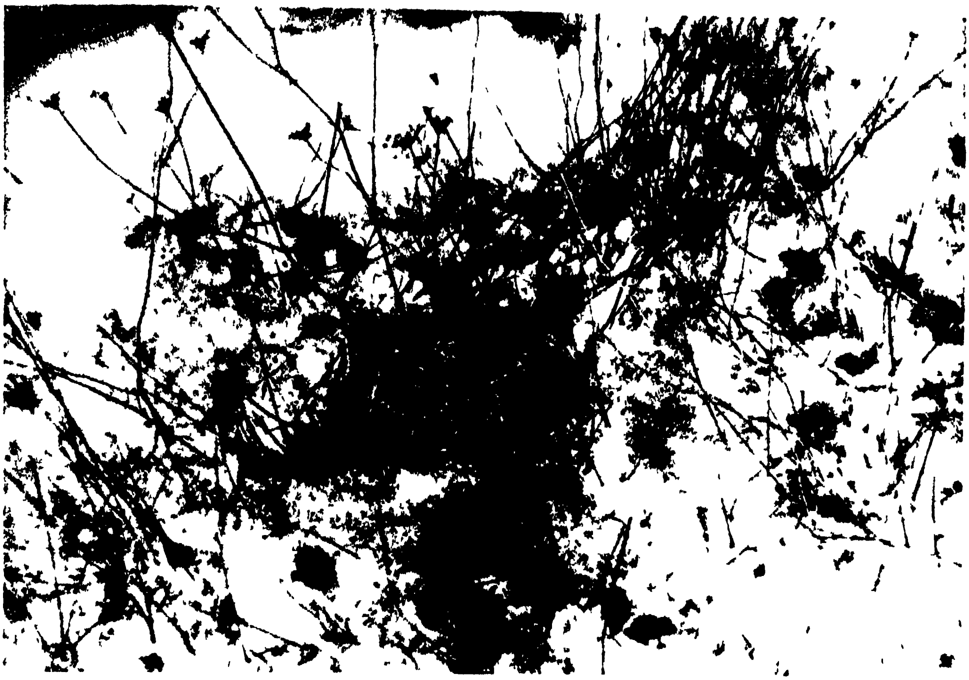
AN IDEAL HABITAT FOR FIELD MICE
UNDER DENSE VEGETATION THEY ARE RELATIVELY FREE FROM HAWKS AND OTHER AVIAN PREDATORS

by gnawing off the grasses and other succulents close to their roots, this results in a smooth highway from which the mice seldom depart At regular intervals occur midden heaps composed of the little green dung pellets deposited by the mice Several mice in a community may repair to these heaps, until the growth of the mound necessitates the establishment of another

In the early spring, before the new vegetation has obscured the partly exposed highways, it is possible for one who remains perfectly still to watch the mice carry on in a perfectly normal manner I once sat in the low crotch of a small apple tree and looked down upon a mouse drama at my feet Some were friendly, touching noses as they met, while other cantankerous individuals would pursue all which approached too near, biting viciously at the heels of the pursued Field mice generally appear to enjoy the company of one another Once a field mouse becomes established in a territory, it seldom ventures far away Several years ago I selected an extensive field which had a large population of mice By using small metal box traps designed to capture the mice alive, I was successful in taking several hundred These were all marked so that each individual could later be recognized Once marked, the mouse was liberated, and after each recapture a record of the place of capture was made The mouse was again released In this manner it was established that field mice seldom encompass an area exceeding that of a tennis court, individuals may often spend their entire lives on a plot not greater than a tenth of an acre [1]

Many animals possess a regular activity rhythm Thus the deer-mouse is active only by night, tree squirrels seek

[1] Hamilton, *Ecology*, 18 259–262



A WINTER MOUSE NEST

THE BODY HEAT OF THE INHABITANT MELTS THE SNOW AND EXPOSES THE SNUG WINTER QUARTERS NOTE THE EXTENSIVE SUBNIVEAN TUNNELS

their food chiefly by day and rest at night Field mice can have little other than cat naps, for they are up and about at all hours By placing a few oat flakes (of which they are inordinately fond) in the runways at many points and recording the time at which the bait was removed, it has been possible to determine when the mice were most active A thousand records made hourly throughout the day and night under natural conditions suggest that these little rodents are most active shortly after dawn and again just before dusk, although there is scarcely any period of the night or day when the mice are inactive [2] These observations are of great importance to one who wishes to control the mice

Feeding Habits

Field mice are preeminently vegetarians To list all the plants eaten by the various species of Microtus would fill the pages of this journal In the timothy field they cut through the base of the long crowded stalks These stand so close that they can not fall, but the mice, undeterred, continue to cut match-length sections away until the plump heads are within reach Thus is explained the little piles of stem sections one often finds in the hay field In the alfalfa field the mice find a rich haven of food and shelter The tough basal stalk is cut through by the little yellow razor-sharp incisors of the mice, bringing to earth the succulent terminal leaves, which are speedily stripped from the stem But these mice, like many other small herbivores, are profligate feeders, and scarcely have they destroyed the greater part of a plant for a hasty meal than their attraction is drawn to another

During the summer food is abundant,

[2] *Ibid.*, pp 255–259

WEEK-OLD FIELD MICE
THEIR EYES WILL OPEN IN ANOTHER DAY, AND A FEW DAYS LATER THEY ARE WEANED

and the mice feed lavishly But there comes a time when the killing frosts of autumn put an end to such variety, and the mice must seek other food Under cover of snow, the mice carry on their subnivean activity, for there is no winter sleep for these active fellows Food, while not so varied, is yet abundant, and the mice remain fat and sleek Where orchard grass is abundant, the mice push into the clump, feasting on the blanched shoots or blades, which remain green far into the winter The wild cherry trees in the hedgerow attract the mice, and with the approach of spring the white girdled bases contrast sharply with the brown bark above We are little concerned so long as the mice girdle only the small trees of waste land, but when they invade the orchards and attack young fruit trees, often destroying great numbers, action must be taken

Their food is not restricted solely to the plant world, for small insects, snails and other minute life provide variety. On the salt marshes there is an abundance of small fry on which these mice feed, and inland the meadows teem with insects which are not scorned by the little rodents Indeed, they are not adverse to eating their own kind, and occasionally turn cannibal

Their appetite is prodigious, and one seldom collects a specimen the stomach of which is not distended with finely chewed vegetation

Captive mice have been known to consume their own weight of green food every 24 hours It is quite possible that their food consumption under natural conditions is equal to this, for the mice have more opportunity to exercise and carry on their normal activities Adult mice weigh from 40 to 50 grams, but the

average weight, including young and immature animals, probably averages about 30 grams. In an alfalfa field, a population of 100 mice per acre (not a particularly heavy concentration) would, during the growing season, be capable of eating nearly 300 pounds of potential hay. This is not in itself a major loss, but, as we have seen, ten times that amount is destroyed in securing the tender tips which most delight the mice.

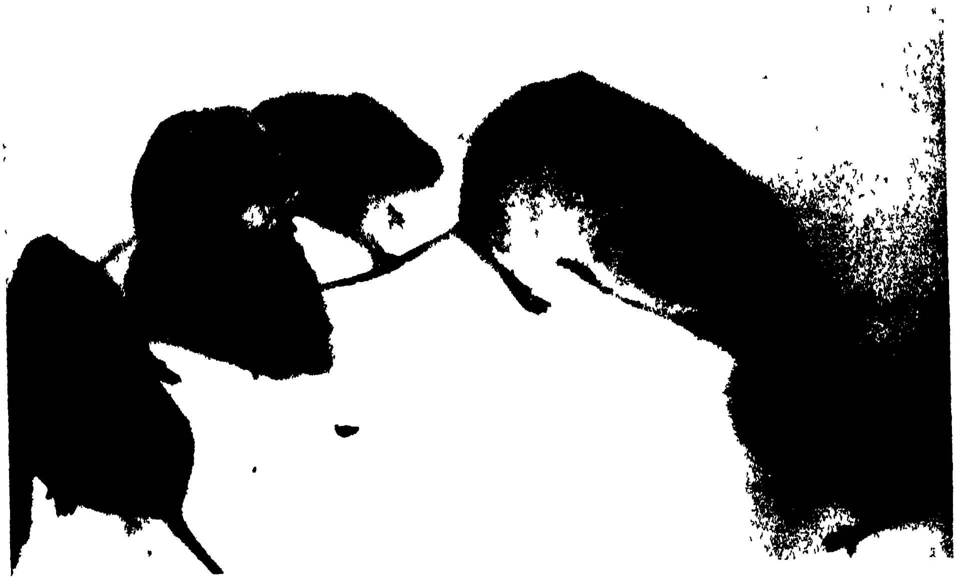
Breeding

The field mice of northeastern United States are the most prolific breeders of all mammals in the world. In years of mouse abundance, one litter follows another in rapid succession, until it seems the meadows and fields will boil over with the little rodents. The mice are promiscuous, females accepting the attentions of any male. Within a few hours after partus, sometimes sooner, the female is again mated. The young, like other mice, are blind, naked and helpless at birth, weighing not more than a penny, but grow rather rapidly. If the nursing parent is alarmed, she will flee the nest, the young clinging desperately to her teats. If one should be lost in this precipitous flight, the mother makes a cautious return, quickly grasps the youngster and makes off to her new quarters. Within a week after birth the teeth have appeared, and the body is covered with a short velvety covering. When eight or nine days old, the eyes open and the youngsters commence to crowd the nest, seeking cover if disturbed. They now take an interest in tender leaves and other green delicacies. The young mice are weaned before they are two weeks old, but usually remain with the mother for a few days longer. Soon it is time for the arrival of another litter, the growing young make off to establish their own quarters and are soon busy with family duties.

Their breeding potential is graphically described by Bailey:[1]

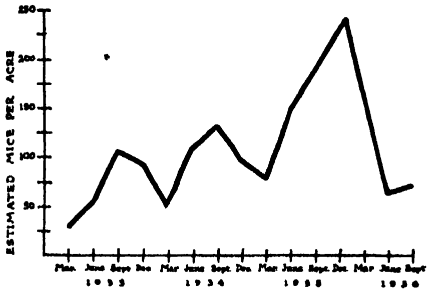
> In captivity the young, if well fed, begin to breed when less than half grown, the females mating with older males when only 25 days old.

[1] Bailey, *Jour. Agr. Research*, 27: 528, 1924.



FIELD MICE ARE THE WORLD'S MOST PROLIFIC MAMMALS

THESE 14 DAY OLD YOUNGSTERS ARE ABLE TO SHIFT FOR THEMSELVES, AND WELL THEY MUST, FOR THE MOTHER WILL PRODUCE ANOTHER LITTER A WEEK HENCE



THE RISE AND FALL OF POPULATION
FIELD MICE INCREASE IN NUMBERS DURING THE SPRING, SUMMER AND FALL MONTHS BUT DECLINE DURING THE WINTER POPULATIONS MAY RISE FOR THREE OR FOUR YEARS FINALLY EPIDEMIC STALKS THE FIELDS AND MEADOWS, AND THE MOUSE MILLIONS ARE DRASTICALLY REDUCED THE GRAPH INDICATES POPULATION TRENDS ON 20 ACRE FIELD OVER A PERIOD OF SEVERAL YEARS

and having young when 45 days old, and the young males mating when only 45 days old The breeding activities are practically continuous, the females mating immediately after the birth of the young and producing litters of usually 4 at first, but when full grown, after the first or second litter, usually six or eight at a birth Seventeen consecutive litters of young have been produced by one female in captivity within a year—May 25, June 14, July 8, July 29, August 23, September 18, October 18, November 9, November 30, December 21, January 12, February 2, February 23, March 18, April 8, April 30, May 20—and then she showed no signs of being near the end of the breeding period, while several generations of her young have busily followed her example, one of them, born on May 25, having produced 13 families of young totaling 78 in number, before she was a year old

Small wonder the fields are so thickly populated!

The attainment of sexual maturity at an uncommonly early age, the very prolific nature of these mice, the attendant cares and physical strain and finally, the ceaseless activity of these small animals in their search for food both day and night all take their toll Trapping records during late winter show an almost total absence of adult mice Inasmuch as long observation does not suggest different habits between the young and old, it has been assumed that there is a high mortality among the mature mice at this season Thus the mice are short-lived, their natural life span in the wild apparently not extending beyond a year, or two at the most [4]

Mouse Populations

Like the snowshoe rabbit of Canada and the lemmings of Norway, empire among the field mice has its rise and fall Incredibly abundant one summer, scarcely a mouse will be seen the following year What occasions these mouse plagues and the drastic leveling which always follows them? Obviously the prodigious reproductive rate can not continue for more than a few years, else the entire earth would be populated with Microtus

Studies[5] in central New York indicate that the mouse cycle usually runs its course in four years The winter of 1931–32 had been a notable mouse year, great damage in the agricultural areas of northeastern United States coinciding with the mouse hordes Little complaint from mouse damage was heard the following winter, and diligent field observations indicated a paucity of mice To be sure, the meadows and fields had small populations of mice during the summer of 1933, but only slowly was a population building up that would again reach its climax a few years hence Trapping records at this time revealed a mouse population which varied between 15 and 40 per acre, depending on the habitat

The following spring mice commenced to breed earlier, and it was noted that the litters were larger than in the two preceding years Moreover, the increasing numbers allowed more opportunity for receptive females to meet fecund males, and the breeding rate was considerably accelerated During the fall

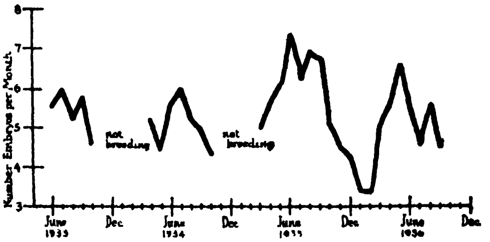
[4] Hamilton, *Amer Naturalist*, 71 500–507, 1937

[5] Hamilton, *Jour Agr. Research*, 54 779–790, 1937

of 1934 mouse populations had increased until the mice numbered 35 to 140 per acre in various habitats. In spite of the cessation of breeding during the winter months, and the normal mortality which always accompanies this season, the mouse population continued to gain. By the fall of 1935 mice were everywhere. Many had been crowded out by their relatives and had left the choicer localities, settling in less favored regions, even venturing some little distance into wood lots, which they seldom choose as a home site.

Previously the mice had continued breeding into late October or early November, but few young and no gravid females had been encountered later in the year than this. During the winter of 1935–36 many of the mice continued to breed, and although the litters were smaller than those of the preceding summer, the additional births largely offset the natural mortality which accompanies the winter months. Mice continued to be extraordinarily abundant, and reasonably accurate census methods revealed there were between 200 and 300 mice per acre in favorite localities (equivalent to about 3 or 4 mice to the living room of a small residence).

Until the early spring of 1936, all mice that were examined appeared to be in good health. During March a decrease in numbers was noted, and an occasional mouse was taken which indicated a diseased condition. Efforts were made to take large numbers of mice alive and uninjured. These were placed in spacious pens. Many of the mice soon became sluggish, the fur stood on end, becoming damp and slightly oily, and lethargy was pronounced. After incipient drowsiness, a characteristic spasmodic twitching of the neck and shoulders was manifest, the animal soon falling on its side. Watery discharges from the vent and gasping accompanied this final stage, the animals thrusting



THE BIOLOGY OF A MOUSE CYCLE

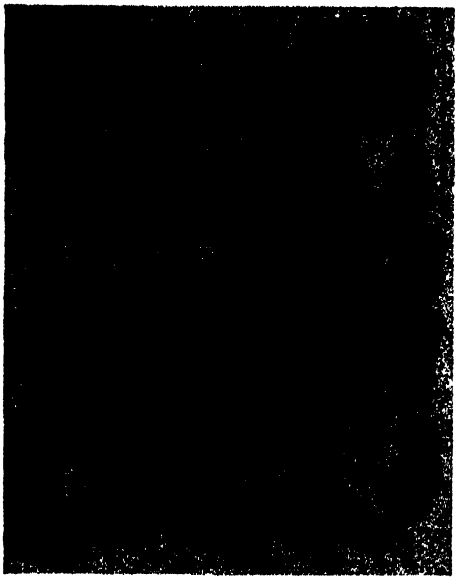
DURING THE LOW OF A CYCLE, BREEDING IS CURTAILED—THE MICE HAVE FEWER LITTERS AND THESE ARE USUALLY OF SMALL SIZE. BREEDING IS REDUCED OR CURTAILED ENTIRELY DURING THE WINTER. AS THE MOUSE NUMBERS INCREASE, BREEDING IS ACCELERATED, THE LITTERS BECOME LARGER AND THE SEASON OF REPRODUCTION IS LONGER. AT THE HEIGHT OF THE CYCLE BREEDING CONTINUES THROUGHOUT THE ENTIRE YEAR. THE PERIOD OF INEVITABLE DECLINE ARRIVES, AND ANOTHER CYCLE IS STARTED.

their hind legs straight backward. Convulsive activity soon resulted in death.

Necropsies were made on all the mice which died. Heart blood was removed under aseptic precautions and transferred to an agar slant, but the medium remained sterile after several days incubation, nor were any blood parasites observed. Many of the mice had large cysticercus, or the bladder worm stage, of *Taenia taeniaeformis* in the liver.

Field mice always have a population of ectoparasites, but the lice, mites and fleas increased tremendously with the progress of the cycle, until at its height more than a thousand mites (*Hoplopleura acanthopus*) were often removed from a single mouse. Investigators in Great Britain have attributed the decline in mouse populations to toxoplasms in the brain. Sections were prepared of fresh brains of sick mice, but no parasite was found. In spite of such negative results, the drastic decline of the mouse population was obviously due to a disease organism.

By early summer the mice were greatly reduced, and those left to breed were not nearly so prolific as during the past year. Their numbers again slowly



MICE FROM A QUARTER ACRE PLOT

DURING YEARS OF ABUNDANCE, THE MEADOWS AND FIELDS OF EASTERN UNITED STATES SWARM WITH THESE SMALL RODENTS, POPULATIONS OF 200 TO 300 PER ACRE NOT BEING UNUSUAL

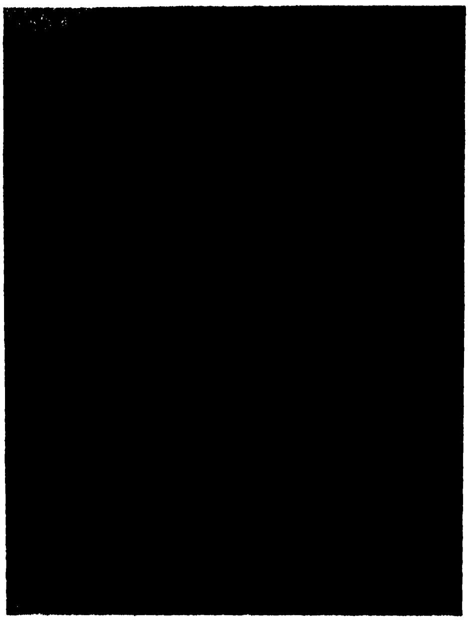
increased, until they were once more extraordinarily abundant during the winter of 1938–39 During the spring of 1939 no diseased mice were obtained, but the mouse population was nevertheless much reduced in the summer of 1939

It should not be understood that the growth in population is the same for every cycle Indeed, some peaks are reached in three years and maintained for another year Plague conditions do not exist with every cycle; it is only when extremely favorable climatic conditions exist, and scarcity of predators and parasites is apparent, that optimum densities are reached Mouse cycles may come and go for several decades before a culmination of favorable factors allows for mass reproduction Moreover, it now seems apparent that cycles in adjacent parts of one state, or in adjacent states, do not necessarily coincide Every locality may have its own cycle, although the 1932–36 cycle coincided throughout all of northeastern United States.

Mass Outbreaks

When favorable conditions prevail, mice often become incredibly abundant and mass outbreaks occur These have attracted the attention of scientists the world over, and there exist many fine descriptions in the literature. Unfortunately, with the inevitable decline, little attention is directed to these animals until another outbreak seems imminent, and as a result little has been recorded on the biology of microtine cycles

Usually mass production of mice accompanies agricultural modification of the land by man In dry countries, where the mice are usually scarce, irrigation and the consequent increase of food suitable for these little animals has enabled them to increase greatly Such a change



DESTRUCTION TO ORCHARD TREES

THIS 20-YEAR OLD APPLE TREE HAS BEEN BADLY GIRDLED BY MICE. DIRT HAS BEEN REMOVED FROM THE TREE BASE TO INDICATE THE EXTENT OF THE DAMAGE. THIS TREE CAN ONLY BE SAVED BY EXTENSIVE BRIDGE GRAFTING

in habitat was probably largely responsible for the 1907 Nevada outbreak, which was the most disastrous this country has ever experienced.[6]

Damage by field mice (*Microtus montanus*) first attracted the attention of ranchmen in the lower part of the Humboldt Valley of Nevada early in the spring of 1906. The following summer the infestation became severe. The movement of the great body of mice onto the rich alfalfa land was a gradual, scattering progression. By October, 1907, a large part of the cultivated lands in this district had been overrun by vast numbers of mice, and the complete destruction of the alfalfa, the chief crop of the valley, was threatened Mice reached their greatest abundance in November, when it was estimated that on the larger ranches there were from 8,000 to 12,000 mice to each acre! Perhaps the reader can picture these hordes better by visualizing 2,000 mice scurrying about a baseball diamond (the infield) Fields were riddled by their tunnels and holes were scarcely a step apart. By midwinter the mice had been reduced to a few hundred per acre.

The damage occasioned by these pests was terrific. Entire fields of alfalfa were so seriously injured as to require plowing and replanting. Individual ranchers estimated their losses at $28,000, $20,000 and $8,000. The entire loss in the valley probably exceeded $300,000.

Mouse plagues are not a result of extensive emigration, as are the lemming hordes of Norway. The large numbers usually develop within the affected districts. Ordinarily several seasons are required to produce a general plague of mice, and damage is frequently noted for a year prior to a serious outbreak When such mass outbreaks do occur, predatory animals and birds are often attracted to the scene, but their numbers can scarcely cope with the great hordes of mice. Their most effective role is in keeping these small rodents in check during years of normal abundance.

[6] Piper, *Farmers' Bulletin*, 352: 5–10, 1909.

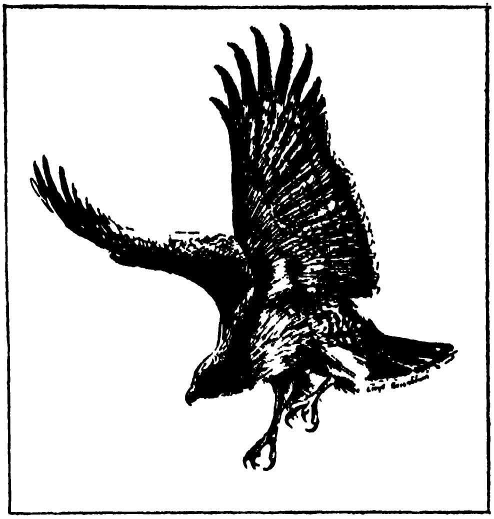
Economic Significance

It is not the great plagues just alluded to which make these mice of such economic importance, but rather the perpetual pilfering of man's crops from year to year. This steady yearly drain, while not particularly obvious, accounts for the loss of millions of dollars to the farmer annually. When grain or corn is harvested and left long in the stack or shock, field mice eventually find it, and establish a residence in this cover, feeding almost entirely upon the kernels. Vegetables, particularly tuberous species, are avidly eaten Nor is the flower bed immune, many herbaceous plants being cut down and partly devoured.

The farmer may ignore the presence of field mice year after year, although he suffers noticeable crop damage from these rodents A time approaches, however, when the mice, favored by ideal climatic conditions, cause untold loss within a few days This is particularly true in orchards, where, under cover of deep snow, the mice girdle the bases of valuable apple trees, causing eventual death of the tree if bridge grafting is neglected Moreover, the damage may be below the ground level, and ordinarily subterranean injury is not suspected until the tree has become so weakened that the damage can not be repaired. Hedges, ornamental shrubs and small pines are peculiarly susceptible to the ravaging teeth of Microtus, but damage is seldom realized until the snow disappears, when useless measures are set afoot.

In spite of what has been said above, we can scarcely condemn these mice as useless pests They serve as food for countless predatory animals. Among the birds, hawks, owls, crows, shrikes, gulls, herons, magpies, jays and many others feed upon them Weasels, skunks, foxes, badgers, bobcats and even the great bears hunt industriously for these mice. Black snakes, milk snakes and other serpents

take a large toll. In the water, to which they frequently resort, pickerel, bass and other predacious fish are ever alert to snap them up Probably no other mammal has such a long list of vertebrate enemies



Seton[7] has aptly stated the importance of these ubiquitous creatures He says:

> The mouse millions (*Microtus drummondi*) are doubtless the boats especially designed to bring food from the mainland of grass to the island of carnivores. Indeed the flesh eaters . . . are far more dependent on the Muridae than they are even on the great ruminants These may furnish an occasional meal, but the mice are the ever-present and reliable hunger-stay, and without them our carnivorous birds and beasts would speedily cease to exist

In addition to these, water, in the form of high tides, inland floods or spring freshets, periodically inundates the meadows, drowning scores of the helpless young in their subterranean chambers Pandemics are forever limiting the mouse population.

Mouse Research

Field mice have such a wide distribution, are almost everywhere so abundant and so readily captured that they are of great interest to the biologist The mice thrive exceptionally well in captivity if provided with a sufficiency of green food, as carrots, potatoes, apples and grasses Oatflakes, melon rind and peanut butter are avidly eaten The field naturalist can provide himself, for a few dollars, with a hundred or more mouse traps and proceed to capture no end of specimens Indeed, the unbaited traps need only be placed across the runways to insure a successful catch, for the mice are totally without suspicion A fine colony may be quickly taken in small metal box traps, or caught in one's hands by pursuing the mice before the vegetation has become too dense Be sure to wear gloves, for the mice can inflict painful bites with their strong little incisors

To the student of cyclic populations, field mice offer a splendid subject for research Their availability to the investigator makes them of additional interest Almost any college campus can boast of a small neglected spot where at least a small colony can be found.

Inasmuch as the epidemics which accompany the decline in mouse populations can now be forecast, an opportunity for research in experimental epidemiology has been opened, both under field conditions and in the laboratory.

[7] Seton, "Life-histories of Northern Animals," pp. 522–523, 1909.

HISTORICAL MAPS AND CHARTS

By JOHN M. McNEILL

CURATOR OF THE MAP AND CHART COLLECTION OF THE U S COAST AND GEODETIC SURVEY

ONE of the most valuable scientific collections of maps, charts and surveys to be found in the United States is that of the U S Coast and Geodetic Survey at Washington The collection consists, essentially, of large-scale hydrographic maps, charts and surveys; of large-scale topographic maps and surveys, of maps of special scientific interest, such as magnetic and seismological maps and charts, maps showing geodetic surveys, etc , and of general and miscellaneous maps and atlases There are, in addition, a number of old, historical charts and maps, many of them of great rarity and value

The collection at present consists of approximately 129,900 items, of which there are 53,582 nautical charts, 120 aeronautical charts (not counting separate editions), 64,158 maps and blueprint maps, and more than 12,000 hydrographic and topographic sheets showing original surveys by the Coast and Geodetic Survey There are approximately seventy-five atlases in the collection

The most useful topographic maps in the collection are the U S Geological Survey quadrangle sheets The library keeps on file a complete set of these Equally useful, though less extensive in areas covered, are the topographic quadrangles published by the Mississippi River Commisison and those by the U S Army Engineers

Another valuable group of topographic maps is the International Map of the World series, on a scale of 1: 1,000,000 This series is far from complete as yet, but the Coast and Geodetic Survey acquires the various sheets as they are published

The library obtains from the government of Canada the topographic maps of the National Topographic Series, which are similar to the topographic surveys of our own country by the U. S. Geological Survey

The library also maintains files of general and miscellaneous maps and atlases for general reference purposes This part of the collection embraces world maps and maps of foreign countries; but the greater part of it consists of maps of the United States and the various states and possessions Many county and city maps are also included.

HYDROGRAPHIC CHARTS AND MAPS

The collection of nautical charts in the Library and Archives consists of a complete set of the bureau's own published charts, a set of the British Admiralty nautical charts, a partial set of the charts published by the Hydrographic Office, U S Navy Department, a set of Canadian charts, by the Canadian Hydrographic Service, a set of the U. S. Lake Survey charts, covering the Great Lakes, part of the St Lawrence River and the lakes and canals of the State of New York, a set of the bathymetric charts of the International Hydrographic Bureau, at Monte-Carlo; and other charts of foreign origin, chiefly French, German, Russian, Danish In addition, the library has a number of rare and valuable old charts, which will be discussed in detail later

The charts of the Coast and Geodetic Survey form a complete chronological series, from the first charts published, in 1835, to the most recent issues A copy of each chart, and each edition of every chart, is kept in the permanent files of the archives. The first chart of the

Atlantic coast was published in 1835; the first for the Pacific coast, in 1851; and new surveys and new chart issues have continued up to the present. The Coast and Geodetic Survey charts, therefore, constitute a historical record, of the greatest value, of the hydrographic and topographic conditions and changes along our coasts.

An extremely useful and valuable part of the map collection is the collection of original hydrographic and topographic sheets representing surveys by the Coast and Geodetic Survey. These maps depict, on a large scale and in detail, the hydrographic and topographic features of the coasts and coastal waters of the United States and Possessions They are indispensible in the compilation and revision of the Coast and Geodetic Survey charts, and, in addition, constitute an invaluable historical record of coast-line and bottom changes along our coasts.

The library has at the present time approximately 23,000 blue-print maps These are, for the most part, maps of surveys performed by the U. S Army Engineers They are large-scale hydrographic maps, covering the harbors and navigable rivers and waterways of the United States They show water depths, shore and harbor lines, navigation channels, dangers and aids to navigation and related hydrographic information.

River Surveys

The interest of the Coast and Geodetic Survey in hydrographic surveying and mapping extends to the navigable rivers of the United States as well as to the coasts and coastal waters There are in the bureau's map collection numerous maps and surveys of the nation's principal rivers For the Mississippi River, the library has a complete set of the maps and charts published by the Mississippi River Commission. For the Missouri River, there is a set of charts by the U. S. Army Engineers, published from 1878 to 1881 Other river surveys by the Army Engineers include the Ohio, the Tennessee, the Wabash, and Illinois and Des Plaines Rivers. The library also has the river maps published by the U S. Geological Survey. In addition, there are numerous river surveys included in the blue-print collection and the "Hydro" and "Topo" surveys, previously mentioned.

Magnetic, Seismological and Geodetic Maps

An item of special scientific interest in the bureau's archives is an atlas or collection of maps and charts relating to terrestrial magnetism. This collection embraces all available maps on the subject, published either in the United States or by foreign countries. It includes the magnetic charts and maps published by the Coast and Geodetic Survey.

These maps by the Coast and Geodetic Survey are published at regular intervals and cover Alaska, the United States and some of the individual states A magnetic declination map of the United States is issued about every five years. About once in ten years a series of maps is published which shows the distribution of declination, dip, horizontal intensity, vertical intensity and total intensity. Magnetic maps of individual states are published from time to time, generally appearing in special reports or publications.

The bureau also maintains a collection of maps and other materials dealing with seismology. These maps show earthquake centers, earthquake zones, distribution of earthquakes for various years, location of seismograph stations and other seismological information

Of particular interest to engineers and surveyors are the maps published by the Coast and Geodetic Survey showing the location, extent and progress of geodetic surveys. These maps show, for the United States and the various states, the extent and progress of triangulation,

leveling, traverse and gravity investigations The maps are revised at appropriate intervals to keep abreast of the field work.

Historical Charts

World charts: Bougainville's atlas. Among the historical maps and atlases of the library's collection, a volume of special interest is De Bougainville's atlas, entitled "Journal de la navigation autour du globe de la Frégate la Thetis et de la Corvette l'Espérance pendant les années 1824, 1825, et 1826 . . par M. le Baron de Bougainville, Captaine de Vaisseau." This volume consists principally of pictures—natural scenery, natural history drawings, coastal views, pictures of ships—but there is a group of maps and charts at the end of the book The charts depict the course of the expedition; the courses of surveying boats where more detailed surveys were made, and show soundings, anchorages, shoal areas and noteworthy topographic features of the coasts The detailed maps cover areas in the Indian Ocean and Australasia; and there is a world map showing the course followed by the expedition around the world The scenes, coastal views and other pictures in this volume are highly artistic and beautiful.

The library has in its files a group of charts published by the firm of James Imray and Son, of London. Those in the library bear dates ranging from 1849 to 1900. They are concerned primarily with the coasts of North America, but include also certain oceanic charts of the Atlantic, Pacific and Indian Oceans, as well as charts of eastern Asia and South America

North America, Atlantic Coast: The English Pilot. The earliest sketches and surveys of the Atlantic coast of North America are to be found in the *English Pilot,* which was originally published in the latter part of the seventeenth century. The earliest volume of the *English Pilot* in the library of the Coast and Geodetic Survey bears the imprint date of 1761 This volume describes "The West-India Navigation, from Hudson's-Bay to the River Amazones," and includes forty-two maps, charts and sketches and numerous coastal views. The maps and charts cover pretty thoroughly, on varying scales, the Atlantic and Gulf coasts of the United States; and although they are inaccurate in detail and exhibit rather meager hydrographic and topographic information, they are of great interest and value historically.

The Atlantic Neptune. The Atlantic Neptune is a collection of charts, plans and views of portions of the Atlantic coast of North America, compiled and published by J F W Des Barres, a British engineer and army officer, during the years 1774 to 1784. These charts cover, with more or less thoroughness, the Atlantic coast from the St. Lawrence River to the Mississippi delta The surveys for these charts were performed, in part, by Des Barres himself, by Samuel Holland, another British army officer; and by various other officers, surveyors and engineers Editions of the Atlantic Neptune were issued in 1777, 1780, 1781 and 1784. In addition, special copies were issued from time to time, consisting of selections from the complete set of charts and views, for the use of masters of vessels who required only the sheets relating to the coasts which they intended to visit.[1]

The Coast and Geodetic Survey's copy of the Atlantic Neptune consists of ninety-five sheets, many of them folded, of charts, plans and views; a page of "General Remarks" (describing the coasts of Nova Scotia and giving sailing directions); a page of "Remarks on the Isle of Sable"; two pages of "Tables," giving location of principal harbors and

[1] J. C. Webster, "The Life of Joseph Frederick Wallet Des Barres," pp. 11–19.

geographic features of the coasts of Nova Scotia The set has recently been rebound, in three volumes, each volume having its original (or photostat of original) contents page, and a sheet of "References" or mapping symbols

The Atlantic Neptune charts exhibit both hydrographic and topographic information They show soundings, coast lines, shoal areas The topography shows streams, roads, houses and other buildings Compass directions and magnetic variation are given Relief is shown by hachures Many of the charts are tinted, showing land areas in light brown Many of the views also are tinted, some in sepia, others in full coloring.

The Atlantic Neptune is regarded as one of the most valuable collections of charts ever assembled or published The charts, generally, are based upon accurate and thorough surveys, and the workmanship displayed in the engraving and printing is of a high order One critic has evaluated the Atlantic Neptune as the "most splendid collection of charts, plans and views ever published"[2]

Blunt's Charts After the Revolutionary War, British charts of the American coasts fell into disuse, and were gradually replaced by charts of American origin. The Navy and the Bureau of Topographical Engineers, of the War Department, engaged in surveys, and produced maps and charts, some of which are to be found in the Coast and Geodetic Survey library Edmund Blunt, later an assistant in the Coast and Geodetic Survey, was engaged, from 1795 to 1836, in the publication of the *American Coast Pilot* He also published numerous charts, covering the Atlantic coast of North America, the coasts of Central America, the West Indies and the northern coasts of South America. These charts bear various dates, ranging from 1813 to 1863

[2] Rich, in his "Bibliotheca Americana Nova," I. 249, quoted in Webster, *op cit*, p. 15.

Pacific Coast: Spanish Explorations. The earliest hydrographic surveys of the Pacific coast of what is now the United States were made by various Spanish explorers. The "Atlas para el Viage de las Goletas *Sutil* y *Mexicana* al reconocimiento del Estrecho de Juan de Fuca en 1782," published in 1802, embodies the discoveries and surveys of many early Spanish explorers. The original of this atlas is in the Library of Congress; but the Coast and Geodetic Survey has a photostat copy of it, received as a gift from Mr. James W. McGuire The atlas contains nine charts and maps, covering the entire coast from Lower California to Unalaska Island.

Vancouver's Explorations. Captain George Vancouver, of the British Navy, made three exploring expeditions to the Pacific coast of North America in the years 1792, 1793 and 1794 His explorations covered the coast from Lower California to Cook Inlet and Kodiak Island, Alaska The Coast and Geodetic Survey has a copy of the atlas which was published from these explorations of Vancouver The set consists of nine detailed charts or maps of the coast; a chart of the Sandwich or Hawaiian Islands, a chart of part of New Holland; a general map showing coastal outlines and depicting the courses of the expeditions, and six sheets of coastal views

The maps of Vancouver became widely known and used They were extensively copied by the famous English cartographer, Aaron Arrowsmith; and later by the British Admiralty, as bases for Admiralty nautical charts They remained in use with but little change until 1850[3]

U S Exploring Expedition. The U S Exploring Expedition was sent by the United States government in 1838 to explore and survey the northwest coast, to visit and examine the Hawaiian

[3] H. R. Wagner, "The Cartography of the Northwest Coast of America to the Year 1800," Vol. I, pp 253–54.

and other groups of islands and to make calls at certain specified world ports. The expedition circumnavigated the earth and returned to New York in 1842.

The expedition was engaged in exploring and surveying the northwest coast, including the Strait of Juan de Fuca, Puget Sound, the Columbia River and San Francisco Bay, from May to November, 1841 The results of these surveys were embodied in maps and charts, the engraved plates for which are in the possession of the U S. Coast and Geodetic Survey

Early Charts of Alaska The earliest explorations of Alaska were made by Russians Bering explored, in 1727, the strait that now bears his name. Again, Bering and Chirikof, in 1741, explored the southern coasts of Alaska and the Aleutian Islands There ensued numerous other explorations, by Russian, Spanish, British and French expeditions Captain James Cook explored the Alaska coasts for England in 1778, La Perouse, for France, in 1785, and, again, Vancouver, for England, in 1793–94 Spanish expeditions were sent out, at various times, under command of Perez, Cuadra, Arteaga, Martinez, Fidalgo and others

The first reliable charts of Alaska were made by Russian authority In 1785, the Russian government sent out a scientific expedition, under command of Captain Joseph Billings, to explore eastern Siberia and Russian America Accompanying this expedition was Lieutenant Sarychef (or Sarichef) of the royal Russian navy. During the course of the expedition, he made surveys of the Alaska coasts, particularly of the Aleutian Islands; and subsequently published the "most complete and reliable charts" of those islands that had ever been published [4] A set of these charts by Sarychef is in the Coast and Geodetic Survey library.

Vancouver, as a result of his explorations of 1793–94, mapped the coasts of Alaska as far north as Cook Inlet and Kodiak Island. These maps are in the Vancouver atlas, mentioned previously.

The charts of Tebenkof, a governor of Russian America from 1845 to 1850, are considered the best and most complete charts of Alaska produced before the purchase of Alaska by the United States. These charts were published by Tebenkof in 1852 They embody the results of all the explorations "of the previous twelve years, together with many of former periods "[5] These charts cover not only the coasts of Alaska, but also the Pacific coast down to the southern extremity of Lower California.

With the cession of Alaska to the United States in 1867, the functions of surveying and charting the coasts and waters of the Territory were transferred to the U S Coast and Geodetic Survey. Surveys were begun by this bureau in 1867 and have been continued up to the present All the surveys, as well as the published charts, produced by the Coast and Geodetic Survey, are to be found in the archives of the bureau

Philippine Islands For the Philippine Islands, the Coast and Geodetic Survey has a group of Spanish charts, published by the Direccion de Hidrografia, at Madrid There are 112 charts in this group, covering, on various scales, the entire archipelago. They range in date, approximately, from 1830 to 1900

Miscellaneous Historical Charts

In addition to the special groups and sets of charts described above, the Coast and Geodetic Survey has a number of miscellaneous old charts, of historical interest Among these is a chart of the coast of Maine, in ten sheets, published by Sewanee Porter, in 1837 (tracing); three charts by Samuel Lambert covering the coasts of New England from Penmaquid Point, Maine, to New London, Connecticut, published 1812, 1813, 1822

[4] H. H. Bancroft, "Works," Vol 33, p. 297.

[5] Bancroft, *op. cit.*, p. 576.

(revised ed. 1847); a chart of Georges Shoals by the Board of Navy Commissioners, 1821; and a chart of Georges Shoal and Bank, surveyed by Lieutenant Charles Wilkes and published by the Navy Commissioners, 1837.

For Boston and Boston harbor, the library has a French chart, dated 1693 (facsimile copy of tracing, obtained from Boston Public Library); a plan of Boston and of Boston harbor, in 1774, published by A O Crane; a chart of "Boston, its Environs and Harbour," dated 1775, made from the observations of Lieutenant Page and the plans of Captain Montresor; and a chart of Boston Harbor surveyed in 1817 by Alexr. S. Wadsworth, of the U S Navy.

Cape Cod and Cape Cod Harbor are shown on a chart prepared under the direction of Major J. D Graham, of the U S Topographical Engineers, in 1833, 1834 and 1835 This map is remarkable for its beauty of engraving and its wealth of hydrographic and topographic detail

A chart by Captain Paul Pinkham, in 1791, shows Nantucket Island and Martha's Vineyard and adjacent coasts and waters.

For Narragansett Bay, there is a chart of 1777 by Charles Blaskowitz; and a chart from surveys in 1832, by Captain Alexr. S Wadsworth of the U S. Navy

A Revolutionary War map, dated 1778, of Sandy Hook and environs shows the position of the British fleet under command of Lord Howe.

Delaware Bay and River are shown on a chart of 1823, published by H. S Tanner, of Philadelphia. A chart of Chesapeake and Delaware Bays, compiled and published by Fielding Lucas, Jr, in 1840, shows not only the two bays mentioned but also the coast and coastal waters from Cape Henlopen to Cape Charles and the rivers tributary to Chesapeake Bay Water depths are shown in the principal rivers, as well as in the Chesapeake and Delaware Bays.

The south Atlantic coast of the United States, from Cape Lookout to Cape Canaveral, is shown on a chart of 1810, by the noted English cartographer, Aaron Arrowsmith. The coasts of North Carolina are represented on two old charts, one by James Wimble, in 1738; the other by Thomas Coles and Jonathan Price, in 1806 A special chart of the North Carolina coast is one of Croatan and Roanoke Sounds, showing the location of proposed embankments and a proposed new inlet, by Hamilton Fulton, in 1820.

Charleston Harbor, South Carolina, is shown on another of Arrowsmith's charts, dated 1810. "Charleston Harbour and the adjacent coast and country" are depicted on a large-scale (1: 15,840) chart by the Topographical Engineers, from surveys of 1823–1825. This chart is very detailed and complete, for both hydrographic and topographic information.

For the Gulf coast of the United States, there is in the library files a "Chart of the Sea Coast of the State of Mississippi, surveyed in 1829, by John Wheeler, Engineer" (published as Sen. 1st Ses 26th Cong Doc. 163)

The Pacific coast is represented primarily by the charts of Commander Cadwalader Ringgold, of the U. S. Navy. He had been a member of the U S. Exploring Expedition, but continued his surveying and charting activities after that expedition was terminated. Of these charts and maps by Ringgold, the following are contained in the Coast and Geodetic Survey's collection· "Farallones Entrance to the Bay of San Francisco, Bays of San Francisco and San Pablo, Straits of Carquines and Suisun Bay, and the Sacramento and San Joaquin Rivers", "the Farallones and Entrance to the Bay of San Francisco"; "Sacramento River from Suisun City to the American River"; "Straits of Carquines and Vallejo Bay"; "Vallejo and Mare Island Strait"; "Anchorage off

San Francisco"; "Anchorage off Sacramento City", "Anchorage off New York of the Pacific"; San Pablo and San Francisco Bays; Suisun and Vallejo Bays. All these charts by Ringgold are dated 1850.

There is also in the library a chart of Suisun Bay and the Straits of Carquines, dated 1850, from the manuscript map by Commodore Thomas Ap. Catesby Jones, of the U. S Navy. Also, for San Francisco Bay, there is a chart of 1789 by A. Dalrymple, taken from a Spanish manuscript; and a chart by G G and J. Robinson, London, published in 1798 The two latter show very little but the outlines of the coast.

Miscellaneous Historical Maps

Coast and Geodetic Survey Civil War Maps. During the Civil War, the Coast and Geodetic Survey (then called the U. S Coast Survey), acting in cooperation with the Union army and navy, performed many surveys and produced numerous maps and charts, of a special military nature. These maps are limited to the territory occupied by the Confederacy. They were invaluable to the Union forces in the prosecution of the war, and now constitute historical records of great value. In matter covered, they range from general topographic maps to sketches showing minute details of battle-fields, forts and fortifications; and from comparatively small-scale hydrographic maps to detailed surveys of harbors, channels and obstructions

Old and Historical Maps in the General Map Files. In the general map files of the library are many old maps of historical worth and interest These maps cover various states and various areas in the United States

Maine. The State of Maine is shown on an old "Map of the District of Maine, Massachusetts," made under order of the General Court and drawn by Osgood Carleton; published by B and J Loring, 1802. The northern boundary of the area is incorrect (not yet having been determined), and the interior is mostly blank Greater detail is shown for the coast and for the more developed inland region paralleling the coast.

New Hampshire New Hampshire is represented by a handsome piece of cartography by Philip Carrigain, dated 1816 The map is detailed and clear, showing all physiographic and artificial features of interest. In addition to the main map, there are a number of artistic hand-drawn views and the following inset maps "The States of the Union east of the Hudson, with the adjacent British Colonies"; "The Middle, Southern, and Western Sections of the United States with the Territories."

Massachusetts A very detailed and thorough map of the State of Massachusetts is Simeon Borden's "Topographic map of Massachusetts . . . made by order of the Legislature," dated 1844. This map shows a wealth of physiographic and cultural detail, all clearly and distinctly represented Appearing as an inset on the same map and bearing the same date is a "Geological map of Massachusetts, made by order of the Legislature," by Edward Hitchcock.

The township of Blackstone, Worcester County, Massachusetts, is shown on a map of 1854, by H F Walling There is also a map of Norton Township, Bristol County, Massachusetts, by the same author, dated 1855. These are comparatively large-scale maps (Blackstone about 60 rods to an inch, Norton 80 rods to an inch), and show all details of the topography Magnetic variation is also shown.

The islands of Nantucket and Tuckernuck are shown on a map of 1838, surveyed by William Mitchell. Topographic and geographic details are shown, including the plan of the town of Nantucket and the location of houses in the open country. Magnetic variation is indicated by a compass rose.

Rhode Island. For the State of Rhode

Island, the library has an old map by James Stevens, published in 1831. In addition to topographic details, this map shows soundings in Narragansett Bay, lighthouses and the ship channel to Providence Roads or turnpikes are shown, with their names; factories, shops, schools, churches, hotels, dwellings and names of inhabitants are shown. Wooded areas are indicated by small pictorial drawings of trees Names of geographic features, including hills, swamps and small streams, are given.

A map of Rhode Island by Henry F. Walling, in 1855, is of especial interest because of its thoroughness and completeness of detail and for the plans of towns which are inserted upon it There are plans of Providence, Newport, Pawtucket, Warren, Woonsocket, Bristol, Greenwich and Westerly Village.

Another map of the state, taken from Walling's surveys, and published by John Douglass of New York, in 1862, also carries numerous city and town plans There are no less than sixty maps of various cities, towns and villages, appearing as insets surrounding the main map

Long Island and New York City For New York City and vicinity, and Long Island, the library has a number of interesting old maps. There is a map of Long Island with the environs of New York, published by J H Colton, in 1836 It is not on a large enough scale (2½ miles to an inch) to show much detail about the city, but roads, houses in the open country and other topographic details are clearly represented A map entitled "Map of the Country Thirty Miles round the City of New York," by I H Eddy, published in 1842, depicts the country surrounding the city; and for New York Bay, shows channels, shoal areas, water depths and lights and buoys. Of similar nature is a map of the country thirty-three miles around New York City, copyrighted 1846, by J H Colton, and the same map with corrections to 1879, published by G. W. and C B. Colton The two latter maps show much more hydrographic detail for New York Bay and harbor than is shown on the Eddy map.

New York City. For New York City, the library has a number of maps of historical interest The earliest of these are two photographic maps from originals owned by the Italian government They are Dutch maps, one being entitled "Afbeeldinge van der Stadt Amsterdam in Nieuw Neederlandt," date depicted 1660, and the other showing Manhattan Island, Staten Island, New York Bay, Hudson River and adjacent coasts of New Jersey and Long Island The date of the situation portrayed by the latter map is 1639

Another map of New York City is entitled simply "New Yorke, 1695," no author being given, but bearing the statement that it was lithographed by G Hayward "for D T Valentine's Manual" in 1851 New York City in 1728 is shown on a map by William Bradford, taken from surveys by James Lyne A map dated 1797 shows details of the city (streets and names, wharves, etc) for that date This map, like the one mentioned above, bears no author's name, but was lithographed by G Hayward "for D T Valentine's Manual," 1853 Another map, copied from the map of D Longworth, shows the city in 1808 New York City in 1851 is shown on a beautifully engraved map of the "City and County of New York, and the adjacent Country," published by Sherman and Smith in 1851 This map shows original shore lines, proposed development beyond the original shore lines and the topography of the area Relief is indicated by hachures, and steepness of slope by degrees of shading. Woods are represented by small pictorial drawings of trees

Two maps that emphasize particularly the topographic and shore-line changes that have accompanied the growth of

New York City are the "Map showing the High and Low Water mark and the original City Grants of Lands under Water made to various parties from 1688 to 1873," by the Department of Docks, 1873; and the "Topographical Atlas of the City of New York, including the annexed territory, showing original water courses and made land," by Egbert L. Viele, 1874 The former shows coastline changes, primarily, together with the successive extensions of pierhead and bulkhead lines. The latter shows not only alterations in the shoreline, but also the original topography of the land, including marshes, meadow lands and water courses Relief is indicated by hachures

New Jersey For the State of New Jersey, the map collection includes a map of "The Providence of New Jersey, Divided into East and West, commonly called The Jerseys " This is a reproduction by the Geological Survey of New Jersey of the original map engraved and published by William Faden, London, in 1777 On this map, the topography is painstakingly and fully shown, relief being represented by a liberal use of hachures Roads, towns and human habitations are shown The dividing lines between East and West Jersey are shown Shoal areas, oyster beds and ship channels in Delaware Bay and River are depicted

There is also a map of New Jersey by William Watson, in 1812, which, although more recent, does not exhibit the fullness of topographic detail shown on the Faden map It shows the dividing lines between East and West Jersey, one, called Keith's Line, surveyed in 1687, the other, Lawrence's Line, surveyed in 1743

A map of New Jersey "compiled under the patronage of the Legislature of said State" by Thomas Gordon, in 1833, is quite detailed, and has a very finished and artistic appearance On this map, cultural features are emphasized—roads, towns, mills, forges, churches, taverns, dwelling houses, canals and railroads being shown. It is on a comparatively large scale (three miles to an inch), so that the numerous details are shown without any appearance of crowding

Pennsylvania The State of Pennsylvania is the subject of a map by Reading Howell, dated 1811 The map shows counties, townships and drainage; and emphasizes the works of man—churches, dwelling houses, forges, grist mills, saw mills, canals, towns, Indian towns, roads, Indian paths and bridle paths being shown This map also gives an interesting picture of the early development of Pennsylvania, the southeastern section of the state, near Philadelphia and the Delaware River, displaying much more cultural detail than is shown on the rest of the map

An excellent early map of Pennsylvania is that by John Melish, copyrighted 1822, corrected to 1832 This is an official map of the state, authorized by act of the legislature, compiled and drawn from official county surveys It is very complete and detailed in every respect.

The city of Philadelphia is shown on a beautifully engraved map of 1796, by John Hills, surveyor and draftsman. The engraving was performed by John Cooke, of Hendon, England The map is on a scale of 600 feet to an inch, and shows details of the city as it was at that time, together with proposed streets and developments The map painstakingly depicts hills, valleys, streams, lakes and wooded areas Street names and numbers are given, and, for the water front, wharves with their names or designations of ownership are shown

Philadelphia and the area surrounding it within a radius of ten miles are exhibited on a map by John Hills, from surveys of 1801–1807 This map embodies a wealth of historical lore, showing names of roads, taverns, inns, churches, location of "gentlemen's

seats" or estates, with names of owners; farms and names of owners; location of schools, dwelling houses and mills.

Maryland. The State of Maryland is represented in the collection by three maps of distinct historical worth. The earliest of these is a "Map of the State of Maryland laid down from an actual Survey of all the principal Waters, public Roads, and Divisions of the Counties therein; describing the Situation of the Cities, Towns, Villages, Houses of Worship and other public Buildings, Furnaces, Forges, Mills, and other remarkable Places," by Dennis Griffith, in 1794. An inset on the main map shows the "Federal Territory" and plan of the city of Washington. The map was engraved by Thackara and Vallance, of Philadelphia.

Maryland in 1840(?) is depicted on a map by Fielding Lucas, Jr, of Baltimore. In addition to full topographic and cultural detail, this map also shows the hydrography of Chesapeake and Delaware Bays and of the Potomac River to Washington

Maryland at the close of the Civil War is shown on a map, produced "under the patronage of the Legislature," by Simon J. Martinet. This map is extremely detailed and thorough, especially in the cultural aspects of the topography. All roads of any consequence are shown, and distances between points are indicated. Mills or factories are shown, and distinguished by note according to product. Hotels, taverns, schools, churches, colleges, blacksmith shops, wheelwrights, mines and quarries and many other details are shown. Churches are distinguished according to denomination by appropriate abbreviations. Chesapeake Bay and the larger rivers show soundings and lighthouses The map is also of interest because of a number of city and town plans inserted upon it. There are plans of Annapolis, Baltimore, Cumberland, Frederick, Hagerstown, and Washington and Georgetown.

The library has a map of the city of Baltimore by Fielding Lucas, Jr., dated 1845, which presents an accurate and clear picture of the city at that date.

Potomac River. There are in the archives of the Coast and Geodetic Survey three maps or tracings of early surveys of the Potomac River. One shows the river from Great Falls to Chopawamsic Creek. This sheet is signed by R. O. Brooke and is dated 1737. The second, entitled "The Platt of Stafford," shows the river from Chopawamsic Creek to Upper Machotich Creek. It is signed by Jno. Savage and is undated. The third shows the Virginia shore from the mouth of Yocomoco River to the mouth of the Potomac; and continuing, shows the Virginia shore of Chesapeake Bay to Rappahanock River, then follows that river up to Morattico Creek This tract was surveyed by William Ball and is dated 1736.

District of Columbia. Maps of the District of Columbia form an important group in the map collection A number of old historic maps of the District have been reproduced and published by the Coast and Geodetic Survey. These include the L'Enfant plant of the city of Washington, 1791; Andrew Ellicott's map of the District, 1791–93; the Dermott, or "Tin Case" map of Washington, 1797–98; and the King Plats of the city of Washington, 1803.

In 1792, Thackara and Vallance, of Philadelphia, engraved and published a map of Washington, a copy of which is in the Coast and Geodetic Survey collection. Another interesting map is the "Plan of the City of Washington. . . . Drawn from the original plan adopted and signed by J. Adams, President of the U. S.," drawn by W. Elliot, in 1822. There is also in the collection a copy of the "Stone Plate" of Washington, engraved by W. J. Stone, about 1839. A feature of this map which is of especial interest is the clarity with which it shows the course of Tiber Creek and its tributaries within the city.

Albert Boshke, at one time an em-

ployee of the Coast and Geodetic Survey, produced some noteworthy maps of Washington and the District of Columbia. His map of Washington published in 1857, in addition to its being a valuable historical record of the city's growth at that time, is an elegant and very thoroughly detailed piece of work. It not only portrays the wards and the street and block plan of the city, but for each block shows the boundaries of lots and the configuration of building lines. Government buildings and other important buildings are shown and named, names of squares are given, and reservations and park lands shown. Soundings are shown in the Potomac and Anacostia (Eastern Branch) Rivers.

A map of the District of Columbia by Boshke, published in 1861 (from surveys of 1856–59), is similarly detailed. It shows all roads, forested and cleared lands, property boundaries and names of owners—in brief, all details of the topography. The plan of Washington on this map is similar to the one described above, though on a smaller scale.

The library has two maps by William Forsyth, a former surveyor of the District of Columbia. One is a map of Washington and the built-up suburban areas, dated 1870; the other, a map of Georgetown, dated 1871 These maps display an unusual minuteness of detail, the Washington map showing not only the customary street names and numbers, important buildings, reservations, and the like, but also showing the dimensions of blocks and sidewalk and building lines. The map of Georgetown goes into still more minute detail, showing the numbers, boundaries and dimensions of individual lots

Later maps of the District of Columbia possessing historical value are those of the District engineer department. Of these maps, the library has a representative set, ranging in date from 1884 to the present time.

The U. S. Coast and Geodetic Survey has published two topographic maps of the District of Columbia, from its own surveys. One is a set of fifty-eight sheets, on a scale of 1·4800, issued at various times from 1881 to 1893; the other, a set of six sheets, on a scale of 1:9600, published in 1894. These maps were originally issued for sale, but are now to be found only in the bureau's archives.

Virginia A very beautiful early map of Virginia in the library's files is that drawn by Herman Boye and copyrighted by John Tyler, governor of the state, in 1826 This is an official map, "constructed in conformity to law," from surveys authorized by the legislature. In information shown, it is very thorough and complete, showing mountains, streams, counties, roads, towns, court houses, mills, minerals, manufactories, iron works, churches, schools and colleges, bridges, fords, ferries, distances between towns, and soundings and depth contours in water areas It also gives a wealth of geographic names, even obscure and comparatively insignificant features being carefully named.

This map, in addition to its cartographic accuracy and completeness, could be classed as a work of art. It is beautifully drawn and engraved, and delicately colored to show counties. On the margins of the map are two elegant hand-drawn and engraved views, one of the University of Virginia, the other of the city of Richmond

North and South Carolina. An item of considerable historical value to be found in the Coast and Geodetic Survey library is a copy of William Byrd's survey of the boundary line between Virginia and North Carolina, in 1728. (This map is a tracing, not the original.)

The Atlantic coast of part of Virginia, North Carolina South Carolina, Georgia and the upper part of Florida is shown on an old map by John Lawson, surveyor general of North Carolina, dated 1709. A very interesting old map of North and South Carolina is one entitled "An Accurate Map of North and South Carolina with their Indian Frontiers, Shew-

ing in a distinct manner all the Mountains, Rivers, Swamps, Marshes, Bays, Creeks, Harbours, Sandbanks, and Soundings on the Coasts; with the Roads and Indian Paths; as well as the Boundary or Provincial Lines, the several Townships and other divisions of the Land,'' etc, by Henry Mouzon and others, published by Sayer and Bennett, London, in 1775

The city of Charleston, South Carolina, in 1844, is the subject of a map published by W. Keenan. The map is in colors, and in addition to the details of wards, blocks, street names and numbers, shows also the names or designations of all wharves and piers.

Tennessee For the State of Tennessee, the library has two early maps, one by Fielding Lucas, Jr, undated, but bearing census statistics for 1810, the other, by Matthew Rhea, dated 1832 The first is on a small scale (about eighteen miles to an inch) and shows little detail except counties and drainage The second is on a considerably larger scale (about seven miles to an inch), and exhibits the minuteness and completeness of detail which are characteristic of carefully made maps of that period

Mississippi River. Besides the maps of the Mississippi River Commission mentioned earlier in this paper, the library collection includes the following old maps of the Mississippi River and Delta, which are of interest and value ''Delta of the Mississippi,'' surveyed in 1838 by the Bureau of Topographical Engineers, showing both hydrography and topography of the delta; and a map of the river from Natchez to New Orleans, by B M Norman, dated 1858 The principal feature of the latter map is its very complete portrayal of property ownership along the river—the boundaries of properties and names of owners being clearly shown. Types of plantations, whether cotton, sugar or other, are distinguished by colors.

Texas The earliest map of Texas in the library files is the ''Map of Texas and the countries adjacent,'' compiled by the Bureau of Topographical Engineers in 1844. It includes the territory from the Mississippi and Missouri Rivers west to the Pacific Ocean; and from south to north, reaches from Tampico, Mexico, to about the 44th parallel of latitude. Little detail is shown, however, except for the areas which now make up the States of Texas, Oklahoma and Kansas. For these areas, names of towns, streams and other geographic features are given, the routes of early explorers and travelers shown and named; and various facts regarding the native Indian tribes given The Pacific coast area shows little except a few geographic names along the coast.

Pacific Coast For the Pacific coast of the United States, the library has a rather numerous group of old maps. The larger part of this group concerns the State of California

California One of the earliest of these California maps is T J Farnum's map of 1845, on a scale of about fifty-two miles to an inch It covers Upper and Lower California, part of Mexico and the area eastward to approximately the 106th meridian It shows mountain chains and water courses, routes of travelers and explorers and location and names of Spanish missions along the coast

A map entitled ''Sketch of General Riley's Route through the Mining Districts,'' dated 1849, shows the coast of California in the vicinities of San Francisco and Monterey Bays, and the inland area to the eastward It is on a scale of approximately nine miles to an inch, and shows considerable detail for coast lines, courses of streams and location and extent of marshes and highlands

A French map entitled ''Carte de la Nouvelle Californie,'' by Hypolite Ferry, in 1849, gives a detailed picture of the territory and its development at that time The map was based upon the explorations and travels of Monsieur Duflot de Morfas and Colonel Fremont.

A map of the "Gold Region in California," by Charles Drayton Gibbes, 1851, constitutes a useful historical record of the state at that time It is carefully and very clearly drawn and shows the physiographic features of the land, villages, settlements, missions, roads, with distances, fords, ferries and other information.

Other useful maps of California in the library files are the following: Maps of California showing public surveys, to accompany the report of the surveyor general, one for 1857 and one for 1860, a map of central California and part of Nevada, by the State Geological Survey of California; a "Map of the region adjacent to the Bay of San Francisco," by the State Geological Survey of California, 1873, a "Map of California and Nevada," by the State Geological Survey of California, 1874, a map of California and Nevada, by Charles Drayton Gibbes, 1876; and a map of California by the U S Geographical and Geological Survey of the Rocky Mountain Region, 1877, showing the distribution of Indian tribes.

San Francisco The library has two early maps of the city of San Francisco, taken from the surveys of William M. Eddy, county and city surveyor, one dated 1850, the other, 1852. A set of maps by the Board of State Harbor Commissioners, *et al*, dated 1877–78, show the water front of San Francisco, with proposed changes. An "Official Map of the City and County of San Francisco," by William P Humphreys, city and county surveyor, in 1870, gives very full details of the plan and topography of the city and county. A copy of the same map revised to 1884 is also in the library. A map by the Board of Harbor Commissioners, in 1876, shows "the salt marsh tide and submerged lands disposed of by the State of California, in and adjacent to the Bays of San Francisco and San Pablo."

Oregon and Washington. The states of Oregon and Washington are represented among the historical maps of the collection chiefly by the maps of the U. S. Exploring Expedition, mentioned earlier in this paper. One of these is a general topographic map of the Oregon Territory, on a scale of approximately fifty miles to an inch It covers the area from Cape Mendocino, California, to Dixon Entrance, Alaska; and from the coast eastward to the Rocky Mountains. Information shown on this map includes the physiography of the area, names and boundaries of Indian tribes, forts, missions, names of geographic features; and an inset map of the Columbia River, on a scale of about twelve miles to an inch.

Washington and Oregon in 1852 are shown on a map entitled "A Diagram of a Portion of Oregon Territory," by John B Creston, surveyor general. This map covers the coast of Washington and Oregon and the area eastward to the Cascade Mountains It is on a large enough scale (about ten miles to an inch) to show considerable information regarding the topography and development of the area

Conclusion

The above outline and description of the U S Coast and Geodetic Survey's map and chart collection, although incomplete and far from exhaustive, will perhaps serve as an introduction to those who may wish to make use of it It should be pointed out that, while the primary purpose of the collection is to serve the bureau itself, it may also be used by interested members of the public, under necessary and suitable restrictions. The cartographic resources of the bureau have been rather extensively used by the public in the past, and such use will doubtless continue and probably increase Items in the bureau's permanent files which may be needed by the public may, unless confidential or restricted, be consulted in the Washington office or obtained in the form of photostat copies

IN REFUTATION OF MR. A. LOVERIDGE ON "ANIMAL TREASURE"

By IVAN SANDERSON, B.A. Cantab., F.L.S., F.Z.S.

LONDON, ENGLAND

HAVING returned from a year's collecting trip in South America, I have only lately seen an article in the January, 1938, number of THE SCIENTIFIC MONTHLY entitled "If the Blind Lead the Blind Shall . . ?" by Mr. Arthur Loveridge on the subject of a book of mine entitled "Animal Treasure."

Considerable weight would be expected to attach to this article as well from Mr Loveridge's position as assistant curator at the Harvard Museum of Comparative Zoology as from its publication in your magazine As the author's intention appears to be primarily to discredit me personally in the eyes of the scientific world and all those organizations which do me the honor of backing my zoological expeditions, I trust that you will permit me the opportunity of replying to it.

I particularly desire to take this step, notwithstanding the length of time which has elapsed since the publication of the article because the gist of it has reappeared in the columns of various papers throughout different parts of the world at different times Frequently Loveridge claims in his articles upon this subject that the reviews of my book "Animal Treasure" made by two well-known gentlemen, Mr. Clifford H Pope and Mr. Hans C Adamson, were unjustifiable.

Referring to these two reviews Loveridge states in his article that he is caused to reflect that a reviewer is in a position of trust, especially when his scientific study for technical knowledge is calculated to lend special importance to his opinions.

As the office which Mr. Loveridge holds leaves no doubt as to this scientific standing, the article which he has written must consequently be judged from the standpoint that he is in that very position of trust himself

In opening his article about "Animal Treasure" Loveridge refers in somewhat loose and inaccurate phraseology to the origin and financial position of my expedition.

May I therefore make it clear that the expedition of which "Animal Treasure" is a popular account was made on behalf of the British Museum, Cambridge Zoological Museum and the University of London, it was made possible by substantial grants from Cambridge University; Trinity College, Cambridge, the Royal Society; the British Museum and the Percy Sladen Memorial Fund. The financial side was also, though to a lesser extent, assisted by my companion, Mr W M Russell, and myself. The expedition returned to England in 1933 with approximately 7,000 specimens.

The scientific results of the expedition have been reported in the journals of several British learned societies.

"Animal Treasure" was written by me in 1935, was published by the Viking Press in America and Macmillan in London, and the fact that over 80,000 copies have been sold indicates that it is not generally regarded as a purely scientific work.

After alleging that the publishers of "Animal Treasure" had been deceived, claiming that Mr. Adamson's and Mr. Pope's reviews were unjustifiable and suggesting that my observations in the field were inaccurate, Loveridge goes on to state that "Animal Treasure" was an attempt at the exploitation of science

and was "to so large an extent a compound of misstatement, misinterpretation, exaggeration, sensationalism and emotionalism" As an opening gambit in an article this is quite good even for a scientist

There is no truth in the suggestion that my expedition to West Africa was for my own gain or otherwise than for the furtherance of science Also Loveridge knew from my correspondence with him before its publication that the book was purely a popular account and not a scientific work, so there can be no basis for suggesting that I had attempted to exploit science

Loveridge himself defines the scientist, which in his article he denies me to be, as a searcher after truth, but the fact that upon that expedition alone I spent a year of serious study in the field and that the written reports of that study were accepted for publication by the leading scientific societies of England is surely evidence not only that I searched after but found the truth

Again, it is somewhat inconsistent on the part of Mr. Loveridge to deny scientific merit to me and to pour scorn upon the expedition when, as happens to be the fact, some of the collection of 7,000 specimens which I brought back are now under his own care in the Harvard Museum of Comparative Zoology.

Loveridge then takes twenty passages from the book to support his claims and he numbers them seriatim and comments upon them For purposes of simplicity I propose to follow his numbering and to reply to his comments paragraph by paragraph.

(1) Loveridge quotes in part from an account in "Animal Treasure" of an incident with a 'spitting" cobra and hereon he makes the observations that (*a*) I never saw the venom fall on my trousers, (*b*) but I described its color (*c*) on the basis of my assumption I imagined its effect on the eyes, and (*d*) I did not attempt to check my theories with the results of known experiments of this venom.

My reply is (*a*) I saw some of the venom fall upon a white muslin hand net and was aware that it had also fallen on my trousers (*b*) My description of its color was as it appeared on the hand net. Mr. Loveridge refers to its color after crystallization as pale yellow or clear amber and himself therefore only by innuendo denies my statement that in liquid form it was brown (*c*) Why not imagine its effect upon the eyes? Loveridge proceeds to state that in one out of six cases personally investigated by himself the recipient of the venom in the eyes was permanently affected and in the five other cases there was an instantaneous but transitory painful reaction. (*d*) As is evident from the quotation there was no theory to check and the only remark which was not a statement of fact is amply justified by Loveridge's own criticism.

(2) Loveridge accuses me of deliberately withholding the name of a harmless snake as disclosing it would spoil the story concerning the steps I took to mitigate the possible effects of its bite.

To begin with let me make clear that the story is a humorous one in which the laugh is turned against myself, and it does not contain any scientific matter or the name of any reptile

One of Loveridge's general accusations against me is my lack of accuracy, but he placed sufficient reliance upon my brief description of the snake to identify it without hesitation as *Bothrophthalmus lineatus,* and he claims that it was so distinctly colored and so common that, according to Dr G. W Harley, even the native women recognize it as harmless

Further, he deliberately misinterprets the story by stating · "Despite the court messenger's assurance that the man would not die—and when natives agree that any creature is harmless one may

be sure that it is — . " whereas the text actually reads, "I enquired of the court messenger whether the animal was deadly. He replied that it was, but that the man wouldn't die "

At the time when I wrote the story and at the time it was published our snakes, which were being handled by Mr. H W Parker, of the British Museum (Natural History), had only been sorted out provisionally Mr. Loveridge knew this from a letter which I had written to him personally prior to his writing his article, in which I had told him that I did not and would not commit Mr H W. Parker to an identification of the snake in question, as Mr Parker had not arrived at his decision

(3) Loveridge denies the accuracy of the dimensions of a spider which I quoted and apparently with some glee claimed to have verified his opinion that I had exaggerated these dimensions by ascertaining from Mr R. J Whittick, who is in charge of the British Museum collection of arachnids, the dimensions of the largest spider which I brought back from my expedition

It so happened that the particular spider mentioned in the book was not amongst those specimens which went to the British Museum and therefore would not have been in the collection under Mr Whittick's charge, despite Loveridge's opinion I maintain that my measurement of the spider was correct

(4) Loveridge refers to my description of a mantis as being absurd when I describe it as being a truly terrifying creature, apparently always willing to engage in a battle even with man Loveridge claims they are delightful little creatures which he apparently likes keeping as pets

This appears to be primarily a matter of opinion and taste, although in support of my opinion of them the mantidae probably display "distance threat and deflection" as defined by Huxley.[1]

[1] *Am Nat.*, 81, September, 1938.

(5) Loveridge states as simply untrue my account that the female mantis is unable to be impregnated by the male without she eats the male.

The fact of the female devouring the male is admitted by Loveridge, but apparently the necessity is denied and in support of my observations upon the point I would quote, among leading entomologists, J H Fabre,[2] who studied the animals in life.

(6) Referring to my general description of the habits of *Potamogale velox* as not having advanced since its discovery by du Chaillu, so that it had become almost a zoological myth, Loveridge denies that the animal is almost mythical and asserts that I have exaggerated *its rarity* either through ignorance or with the object of magnifying the achievements of my expedition

The paragraph from which Loveridge quotes in part shows when read as a whole that it is the absence of knowledge concerning the life and habits of *Potamogale* that prompted me to call it almost mythical and not the absence of knowledge of the existence of the animal which is specifically referred to. In the text of "Animal Treasure" (p. 228) I actually state that du Chaillu's account of the habits of the *Potamogale velox* were inaccurate, that little or nothing has been done to elucidate its habits since his time, that very little material about it has been collected for study, and no pictures of it have ever been taken in life This is an exact statement of the position as a perusal of extant literature will prove. Its anatomy is almost entirely unknown, Dr J. A Allen, who, according to Loveridge, "extensively discussed" Potamogale material from the Lang Chapin expedition, actually remarks "While *Potamogale* is a rather common animal in its native haunts, it is one of the rarest in collections. . . ."[3] He nevertheless adds nothing to our

[2] "Souvenirs Entomologiques," ser. 5, p. 307.

[3] *Bull. Amer Mus Nat. Hist.*, 47: 4–8, 1922.

knowledge of *Potamogale* except a list of specimens with measurements.

One of the specific purposes for which we went to Africa was to collect spirit material there in order that this lack of knowledge might be rectified. We were successful.

(7) This perhaps is the most important and inaccurate of Loveridge's criticisms He states that I have blundered and talked "utter nonsense" when he quotes from my book that.

> We captured six diurnal animals in Africa that belonged to groups all the other members of which are exclusively nocturnal. All six animals—a snake (*Gastropyxis senaragdina*), a squirrel (*Funisciurus poensis*), a monkey (*Cercopithecus pogonias*), a rat (*Oenomys hypoxanthus*), a flying squirrel (*Anomalurus beecrofti*), and, finally, a lemur (*Galago demidovii*) —were bright green above and yellow beneath, whereas their near-related and nocturnal species were all of other colours. (p 167)

He states that the snake, squirrel and monkey belong to diurnal groups and none of the animals conforms to my description except the snake, and "by courtesy" the squirrel.

I regret the necessity of correcting Loveridge in these observations, as all the animals referred to are bright greenish above and yellow below (see also *Trans Zool. Soc Lond* (1939) Vol xxiv, Pt vii, No 1, now in the press) They still show the full yellow in the preserved specimens at the British Museum The dorsal coloration has faded (as green always does) to olive or dusty-grey-olive.

Loveridge states that the pelage of mammals undergoes no radical changes on preservation beyond a slight dulling and fading with the passage of time, but here again, I would point out that the reaction to which I have referred is, contrary to Loveridge's view, well known Although Loveridge claims that mammalogists support this view of his, I would refer him and those mammalogists supporting him to any collector, taxidermist or museum worker for a contrary opinion

The importance of Loveridge's criticism in this respect is that in one detail he is right. "Animal Treasure" quotes the monkeys (*Cercopithecus*) as being a nocturnal group Loveridge is correct in stating (and I appreciate this accurate and constructive criticism) that it is a diurnal group

In regard to the remaining species my statements are correct so far as refers to West Africa, where I have seen and figured the animals in life Loveridge in his article does not claim to base his contradictions upon personal observation, but relies upon information which he has derived from others and a mere study of museum specimens which is apt to be misleading

For a scientist like Loveridge to jump to a conclusion that I use scientific names without really knowing the creatures to which they refer as he does in referring to the water mongoose (*Atilax paludinosus*) shows that his investigation must be somewhat superficial and his argument weak He denies my description of this animal as being cross-striped, and I can only say that if he would visit the Cameroons and make the acquaintance of these animals he would find that the description is peculiarly applicable to them in their young and sub-adult stages

(8) For the full text of this criticism it would be necessary to refer to Loveridge's article, but it may perhaps be summarized as stating that Loveridge alleges that my statement in "Animal Treasure" that the skincoid lizard (*Lygosoma fernandi*) emits a noise is untrue

The facts as stated in "Animal Treasure" were that on our returning from an expedition towards the end of the day we heard an extraordinary noise, something like a foghorn and we set off to discover what it was. After a fairly

long search and with an element of good fortune we discovered it came from a hole in the ground out of which we extracted a lizard. The lizard was injured in the course of its extraction from the hole in the ground, but before it expired, while I was holding it in my hand, it again emitted (though this time, as was natural, faintly) the sound we had heard before.

At another time I captured two of these lizards and kept them in a cage in the camp and again I heard issue from them the same noise which had originally attracted our attention.

Loveridge suggests that it is ridiculous that an animal measuring eight inches from snout to base of tail could perpetrate so great a noise as did this lizard, but I would remind him that there are Cicada only two and one-half inches in length that can be heard for two miles in Sumatra and that even in thick forests the calls of tiny lemurs (Galagos) and many birds can be heard for miles Having denied the sources of the noise as being what we describe Loveridge himself suggests an explanation, and his explanation is remarkable, namely, that the noise we heard was made up by two sounds, presumably coinciding simultaneously, one being the shrilling of crickets and the other being the whistle of Secret Society men in the forest I feel that Loveridge is taxing the credulity of his readers very highly indeed in introducing an explanation of such a romantic form It appears to indicate that any theory is more probable than that which is supported by the statements of myself and my companion who were on the spot

(9) Loveridge refers to my description of an encounter with "Baboons" (*sic*) as being my first encounter with drills in the primeval forest and consequently being about as trustworthy as the account "of the alarming honking and apparent intentions of the automobiles around it" which a baboon would give assuming it strayed into the middle of Fifth Avenue. And then Loveridge calls me an imaginative young man!

It is true that the anecdote in question was purely humorous and of no scientific value, but in reply to Loveridge's theoretical question in his criticism (not a review, let us remember) "Who has ever heard of drills attacking a man," I would mention that in this self-same primeval forest (not Fifth Avenue) a young woman had, only a fortnight before the incident related, been killed by a troop, possibly the same one, of drills (*Mandrillus leucophaeus*).

(10) In support of his claim that I am unreliable as a scientist Mr Loveridge states that I can not even copy accurately from other authors.

In "Animal Treasure" I referred (without quoting) to Mr. G. L Bates as having found a *male leaf toad* (*Nectophryne batesi*) sitting on a brood of eggs. Quoting from Dr G. A. Boulanger[4] Mr Loveridge claimed that Mr. Bates had found a female with empty oviducts under the trough or hollow of a plantain-leaf petiole crouched in the midst of a mass of eggs.

I accept Loveridge's quotation; but Dr. Boulanger's description is taken from Mr Bates's original field notes. We, however, had cause to examine this actual specimen, which is in the British Museum, and it proved to be a male This discovery was made by Mr H. W. Parker, who published it in "Proceedings of the Zoological Society of London" (1936, p 135), a copy of which was sent to Loveridge on publication. Presumably, however, Loveridge, before embarking upon his criticism of "Animal Treasure," failed to study the extant literature.

Further, Loveridge's statement that the eggs were "beneath the base of a banana leaf apparently lying on the

[4] *Ann. Mag. Nat. Hist.* (8) 12, p. 71.

ground" is a quite unwarranted addition to Bates's note. A plantain-leaf petiole, it is elementary to point out, is customarily several feet from the ground.

Loveridge might have verified these facts while he was so busy collecting information before suggesting that I was unable to "copy from other authors without adding fantastic flourishes from" a "fertile imagination"

(11) In a lengthy series of quotations extracted from their context Loveridge seeks to prove that my method of selection of a companion on my expedition was a failure.

First, I should have thought that this was a question which the leader of the expedition was better able to decide than one who took no part in it Secondly, it is highly improbable that a person who would prove to be a sympathetic companion to Mr Loveridge in the field would possess those characteristics which enabled Mr Russell and myself to achieve the successful results which my expedition brought back.

(12) Loveridge refers with disapproval to my use and enjoyment of the gramophone when working in camp in the jungle

This again is a matter of personal taste and opinion, but it would hardly seem to be relevant as a criticism upon my standing as a scientist.

(13) With more of that sarcasm to which his readers by this stage of the article must have been becoming hardened, Loveridge quotes at length from my description of the drift of life in a tropical forest, and claims to compare it with the drift of ideas in my mind when I was a child

The explanation regarding the drift of life (which Loveridge does not attempt to disprove) is sufficiently apparent from "Animal Treasure" (p 75), and from considerable work in the field in other tropical forests I am able to confirm it, despite Loveridge's scepticism.

(14) Loveridge takes me to task for stating in the early part of the book that in my opinion scientific methods of collecting animals were out of date and that I had a new idea for collecting. Later on he quotes me as employing all the time-honored methods and of shooting promiscuously although I had stated that "we went not to shoot"

I particularly desired not to, and in fact did not, disclose in this popular work the scientific methods of collecting which I did employ Loveridge is therefore at a disadvantage in trying to criticize them.

We did shoot at hawks frequently for sport and it was also necessary to prevent them from trying to steal our stuffed specimens from the drying boards, which they not unnaturally imagined to be real full-blooded animals.

Our primary object was to study the animals in life and any one who compares our scientific reports with those of previous expeditions will see that they are based upon a study made from an entirely different point of view.

(15) Loveridge states that "Animal Treasure" does not bear out a claim made for me by one of the reviewers that it is evident that I love animals.

I personally have never put forward such a claim I do not love animals as animals, although I am intensely interested in them Upon the other hand I abhor cruelty in any form

Loveridge quotes two instances from the book in which reference is made to an adder and frogs being drowned in alcohol and points out that a humane collector would have chloroformed his victims. In reading a popular book the public does not like being led through an involved description of detail and therefore the method of dispatch of the animals in question was not fully described as it would have been had I been writing from a purely scientific point of view.

In fact, all my herpetological specimens (which Loveridge calls "victims")

were first of all chloroformed before being "received into the all-absorbing alcohol."

(16) Loveridge seeks to prove that my views upon Mission work in Africa are such as to vitiate my views upon the mantis and the spider

Although it can have nothing whatsoever to do with my merits or demerits as a scientist, Loveridge is quite open to differ from me in his opinion as to the method and work of Missions in West Africa, but there is no ground whatsoever for the statement which he perpetrates that I have "rejected the claims of Christ for myself" This can be nothing but a gratuitous piece of personal offensiveness for which there is no foundation

(17) "Animal Treasure" claimed that nature in the unspoiled jungle, in the part of West Africa to which I was referring, is far more beautiful than those parts of it in which the white man has settled Loveridge occupies this section of his criticism by expressing a contrary opinion He is quite at liberty to do so, but it is not a helpful basis for scientific criticism

(18) Loveridge states that I have caused incalculable injury to natural history by disseminating false information which is and will be quoted far and wide

I thank him for the compliment as to circulation, but I maintain that substantially, with the one exception which Mr Loveridge has pointed out, "Animal Treasure" is accurate

(19) Loveridge summarizes his conclusion by stating that I am not a scientist Evidently he has arrived at this conclusion from reading a popular book and in fact of prejudging a matter on insufficient material, a fault of which he accuses me in his criticism No 16.

I hope that if only as a matter of courtesy he will read the scientific reports of the expedition in question.

(20) Loveridge says. "We all make mistakes."

It is satisfactory to know that with his last criticism at any rate we are in mutual agreement

The merit of Loveridge's attack on Mr Pope and Mr Adamson arising out of their review of "Animal Treasure" may now be judged in the light of the criticisms which he has made concerning that book I would repeat that the book has never been claimed by its author as a purely scientific work nor was it reviewed as such by Mr Pope and Mr. Adamson, it is a popular introduction to the public of some of the wild life of West Africa

The intelligent questioning of new facts reported by collectors is very beneficial, making as it does for more careful future observation and more detailed and meticulous notes. The sweeping and uncompromising criticism which assumes that every original affirmation must be either an exaggeration or frankly untrue if it is not already known to the critic, even though the critic has little or no field experience of the area under discussion, tends to make abortive any serious endeavor to extend our real knowledge of natural history.

LEAD SHOT: ITS DANGER TO WATER-FOWL[1]

By THOS. L. G. OSMER

MINNESOTA DIVISION OF GAME AND FISH AND UNIVERSITY OF MINNESOTA

EACH year since the first fowler in America fired his muzzle-loading shotgun at a duck, water-fowl areas throughout the nation have been increasingly peppered with shot. Each year produced more and more duck hunters who, instead of using the old muzzle-loader, developed the modern double, repeating and automatic shotguns with smokeless powder and high velocity shells Thus to-day, during the season, every duck flying over a blind is usually accompanied by a shower of shot, whether he is in gun range or not

If a duck survives a hunting season, the chances are becoming increasingly greater that he will pick up, on his feeding grounds, enough lead shot to cause death by lead poisoning This grave danger is not seasonal, like hunting, but is a threat whenever the duck is feeding Nor is the shot covered up by sediment as rapidly as one would hope, but usually remains available to water-fowl for many years It has been experimentally determined that the ingestion of six No 5 shot by a duck is fatal, and even two or three shot are often fatal

Lead poisoning of water-fowl is not new In 1842 a paper was published in Berlin on the injurious effects of lead upon animals In the February, 1894, issue of *Forest and Stream* Dr George Bird Grinnell, famous hunter and naturalist, published an article on lead poisoning of water-fowl in Texas and North Carolina In 1919, Dr Alexander Wetmore investigated western duck sickness and lead poisoning in the water-fowl of the great marshes of the Bear River in Utah In addition to other valuable information he discovered that six shot fed to a duck were always fatal A partial bibliography of no less than 47 titles on lead poisoning of water-fowl is on file in the United States Biological Survey at Washington

Many water-fowl refuges in the state of Minnesota and doubtless throughout the nation were old and much-hunted duck lakes long before they were declared refuges While such a refuge affords safety from hunters it may be a veritable death-trap for water-fowl because of the presence and availability of the old lead shot on the bottom This potential death by lead poisoning, while ever present, is greatly increased during the hunting season because water-fowl tend to concentrate on refuge areas during this period Furthermore, death by lead poisoning becomes an ever greater danger if refuge lakes are located on areas where there is a scarcity of native gravel suitable for consumption by water-fowl Grit is as essential and vital to water-fowl as food and water, and if the grit is abundant and readily available it is eaten in liberal quantities and passes through the digestive systems more rapidly Under conditions of grit scarcity the grit may be conserved and ground over longer periods of time. When grit is ingested in abundance the lead shot picked up also have greater opportunities of being passed through the digestive system before their poisoning effect can be felt. Apparently a duck does not discriminate between a lead shot and a piece

[1] Paper No. 412, Miscellaneous Journal Series, Minnesota Agricultural Experiment Station Cooperative investigation supported by Division of Entomology and Economic Zoology, University of Minnesota, and the Minnesota Conservation Department, together with aid from the Work Projects Administration (Project No 665–71–3–69).

of granite or quartz of the same size. If it did, lead poisoning, the most serious disease problem in water-fowl management to-day, would not exist.

With the foregoing in mind it seems to be very poor water-fowl management to turn old duck-shooting areas into refuges without first determining the relative amounts of shot and gravel that are available to water-fowl. Based upon this premise an investigation was begun to examine, methodically, lake-bottom samples and to study the availability of lead shot and gravel to water-fowl, the chief interest being lead shot

The samples in the study were taken either with a Peterson dredge, such as is used in limnological work, or with a post-hole digger. For each sample the amount of bottom surface covered was one square foot Precautions were taken to sample only the five to six inches at the surface of the lake bottom, that area in which the water-fowl are most accustomed to feed.

As the ice ranged from three to 30 inches thick a crew of WPA laborers was obtained to assist by cutting the holes through the ice The lakes studied were either transected at right angles by two lines of holes or a series of holes was made around the entire lake as close to shore as possible.

This method was used on all the duck lakes surveyed except Heron Lake. Because of the large size of this lake—20 miles long and one mile wide—it was planned first to take samples from several areas that were most heavily hunted and then to take samples of the entire lake in the manner in which the other lakes were surveyed However, circumstances prevented completion of these plans and only four heavily shot areas were surveyed with a total of 36 samples Probably a more accurate picture of lead-shot conditions on Heron Lake could have been made if 100 or more samples could have been taken.

A rough map was drawn of each lake, and the number and location of each sample was recorded when it was made. Each sample was given a tag indicating the name of the lake, number of the station, depth of water and type of bottom. By so doing it was possible to determine, roughly the distribution of the shot over a given area or the entire lake. It was found that the shot was more or less evenly distributed on the bottoms of those lakes examined. The size of the area over which a single charge of shot is scattered is so great that a rather general distribution of spent shot over a lake bottom is assured Tests under field conditions showed that the shot from a 16-gauge high velocity shell may carry nearly 300 yards and that the pattern may be spread over a distance of 48 yards.

After the samples were washed through special sieves in the laboratory the residue of shot, seeds, gravel, small snails, clams, etc , was dried and separated into vials for further study In those samples containing lead the shot was counted and the amount was added to the corresponding tag. The duck lakes surveyed represented both those closed to hunting and those on which hunting still occurs By so doing it was possible to make a comparison of lead-shot conditions in the two kinds of lakes.

In three lakes in the Carlos Avery Refuge in Anoka County, Minnesota, much of the lead shot from past years' shooting still lies within a few inches of the surface of the lake bottom and is undoubtedly available to feeding water-fowl In two of the lakes, Little Coon and East Twin, at the time of the study no shooting had been allowed for five years, and, in spite of this, shot were recovered from the bottom samples at the rate of one shot per 3 5 square feet, and one per 1.66 square feet, respectively. These averages are based upon 28 and 25 samples

The third lake within the refuge, West Twin Lake, was protected from all shooting for four years, but had been opened to hunting for one year at the time the work was done. Here 27 samples yielded 12 shot or an average of one per 2.25 square foot, a figure quite comparable with these from the other two refuge lakes.

Three nearby lakes on which ducks are hunted were studied for comparison They were Boot Lake, Rice Lake and Tamarack Lake, all in Anoka County within three miles of the Carlos Avery Refuge Lakes The incidence of shot varied from one per 1.25 square feet in Rice Lake to one per 8 square feet in Boot Lake, but the average for these three lakes, all continuously open to hunting, was one shot per 2.04 square feet The distribution of the shot over the six lakes was general.

To make matters worse, there is a very marked scarcity of gravel in the Carlos Avery Refuge lakes In fact, because of its geological formations the major portion of the entire county has very little native gravel available or suitable either to water-fowl or upland game It seems logical to assume that any duck lake, refuge or otherwise, which has a very marked deficiency of gravel for water-fowl but at the same time has lead shot easily available is that much more dangerous to water-fowl, and the total amount of gravel in the 80 samples taken on the three Carlos Avery Refuge lakes weighed but 2.3 grams. Over 37 per cent. of the total number of samples from these refuge lakes were entirely devoid of gravel Since the average duck gizzard contains two to three grams of gravel, a duck on these lakes would have to cover at least 80 square feet of lake bottom in order to find sufficient gravel for his needs. However, the same duck has but to forage 15 square feet in order to find enough lead shot to cause death by lead poisoning!

Such a condition as that found on the Carlos Avery Refuge lakes *might* be partially remedied by simply distributing gravel of suitable size and kind on the lakes during the winter months. In the spring when the ice melts the gravel sinks to the bottom and is thus available to water-fowl

Heron Lake, Jackson County, Minnesota, is located about 150 miles southwest of Minneapolis and 10 miles west of Windom This lake has been a famous water-fowl hunting area for over 75 years. At one time it was one of the greatest canvas-back lakes in the state, but since practically all the wild celery has disappeared very few ducks of this species visit it To-day it is a favorite mallard lake.

Heron Lake is divided into three parts, the smallest of which is on the north end and is called Duck Lake The other two make up the bulk of the main lake, and all three comprise an area approximately 20 miles long by one mile wide The average depth of the portions studied was between 18 and 24 inches The bottom is hard clay with one to three inches of mud on top The dominant vegetation is river bulrush (*Scirpus fluviatilis*), which has but slight value as a duck food. About 2,000 seeds of this aquatic plant were taken from only 36 samples. Gravel, suitable for water-fowl, was not scarce, only four out of the 36 samples being without grit. The 36 samples were taken from four different areas that had been hunted most intensively during the past years

Only one of the four samples taken on Duck Lake contained lead, but this amounted to three shot Three samples taken from the west side produced a total of four shot Twelve samples of the 23 taken on the southeast and south sides of upper Heron Lake yielded a total of 46 shot. One of these samples, covering one square foot, contained 11 shot!

The average density of shot on the total area surveyed amounts to 1.5 shot for every square foot of bottom. While this

density is very high, it perhaps would be higher and more general in distribution if the lake were open to public hunting For many years the entire lake has been leased to individuals and groups of hunters who shoot over definite areas and prevent the general public from entering their private domain

The bottom of Heron Lake would keep lead shot easily available to water-fowl for many years to come, even though a shotgun were never to be discharged over it again. The rate of deposition is very slow, as revealed by a thin covering of mud These two factors, especially when combined with heavy hunting, constitute a great lead-poisoning hazard for water-fowl

Very little can be done to lessen the danger of lead poisoning on a lake of this type To stop the increase of lead by closing Heron Lake to hunting would be futile because the water-fowl would only concentrate on it during the hunting season, causing a more severe increase in lead poisoning mortality than already exists Such a procedure would also meet a tremendous opposition by those who hunt the lake Such drastic measures as trying to cover the lead or remove it would not only be economically impractical but would destroy valuable water-fowl foods for several years to come

Most water-fowl lakes in Minnesota may be classified into three major groups tamarack-bog lakes, like Rice and Tamarack lakes in Anoka County; prairie lakes, like Heron Lake and those on Carlos Avery Refuge; and river-lakes, like those common along the Minnesota River The lakes surveyed to date fall into these three classes and are typical of each class

The river-lakes surveyed for lead shot and gravel available to water-fowl included five large lakes on the Minnesota River, owned or leased by private gun clubs The Minnesota River Gun Club, which owns one lake, is located across the river from the west end of Fort Snelling, in Dakota County. The Long Meadow Gun Club controls two lakes, and is located south of Minneapolis, in Hennepin County. The Benz Club owns two lakes, and is located on the south side of the river and a few miles downstream from Shakopee The level of these lakes is usually maintained by dams and springs.

The data reveal that of the three major classes of duck lakes the river-lakes have the least lead available to water-fowl, an average of one shot per 2 97 square feet in the 107 samples from three areas studied This fact may be due chiefly to three factors. First, river-lakes in general have the highest rate of deposition of any type of duck lake because of the annual flooding of the river, thus the shot is more rapidly covered up and made unavailable to ducks Second, practically all the hunting on these three areas is pass shooting, thus less shot falls in duck-feeding areas on the lakes. Third, these particular lakes have been leased or owned by private parties for many years, and therefore the number of hunters per season and per day is limited Thus less shot is scattered over the feeding grounds for the ducks to pick up

If these river-lakes were open to the public a far greater incidence of lead shot would undoubtedly occur, as all three areas are within 30 miles of the Twin Cities The data reveal also that the river-lakes have more gravel available to water-fowl than the other types of duck lakes surveyed

In addition to the lead shot recovered from the bottom samples, a total of 24 species of aquatic plant seeds were found The number of species in each lake ranged from two to eleven Such important water-fowl foods as *Sagittaria, Scirpus, Najas, Polygonum, Zizania* and nine species of *Potamogeton* were identified.

The number of shot found in this study show how widely distributed and easily

accessible to water-fowl lead shot are, and how important is the need of control. Professor R. L Dowdell, of the School of Mines, and Dr. R. G Green, of the School of Medicine, both of the University of Minnesota, have devised an alloy of magnesium and lead to be used in the manufacture of shot Shot made of this alloy disintegrates rapidly in water due to the action of magnesium Even if these small particles of disintegrated lead are picked up by a duck they are not retained in the gizzard. Whole pellets eaten by the bird decompose into small fragments, which are almost completely eliminated in 48 hours This non-toxic shot in no way affects the pattern of a modern shotgun It appears to offer an early solution of the problem. The data here presented emphasize that when the commercial production of a non-toxic shot becomes feasible the change should be made even if compelling legislation is necessary to assure it.

Little can be done about the shot that already lies on the bottoms of many thousands of duck lakes throughout the nation; therefore, in conclusion, it seems that setting aside an old hunting area for a duck refuge, as has often been done, is not wise if the bottom of that particular lake has in it considerable lead shot available to water-fowl To allow ducks to concentrate during the hunting season on a refuge full of available shot is comparable to turning broods of quail or pheasants into coops contaminated by disease. Before any water-fowl area previously used for duck shooting is declared a refuge, a thorough survey and analysis, of at least the feeding grounds of that area, should be made to determine the relative amounts of lead, gravel and food available to water-fowl

EDUCATION OF MEDIOCRE PERSONS

There are those who believe that it is to day too easy rather than too hard for mediocre persons to be carried forward into careers which demand something very different from mediocrity Institutions of higher education have numberless fellowships and assistantships at their disposal It is not hard to find government help these days, and a recent summary made by the National Research Council lists some 450 research appointments made annually by industrial organizations for work to be carried on outside their own laboratories and with only incidental reference, if any, to their own immediate interests. . . . Only in a few strong professions, notably medicine and law, and the older branches of engineering, can it be said that possession of a degree to-day necessarily means anything Elsewhere, all too often, a degree as such may mean literally nothing All over the country teaching and other vacancies are being filled by degrees, not by men or women, the appointing bodies accepting the diploma as a substitute for the tiresome process of really finding out something as to the professional and personal qualifications of individual human beings. Sometimes the situation presents curious anomalies, as in the fine arts, where the possession of a Ph D, however much it may imply as to scholarly knowledge, all too often reflects the absence of creative interest and capacity on the part of the possessor —*Report of the President of the Carnegie Corporation of New York*

COLLECTING METEORITIC DUST

By Dr. H. H. NININGER

CURATOR OF METEORITES, COLORADO MUSEUM OF NATURAL HISTORY

FOR more than a century sporadic efforts have been made to collect meteoritic or cosmic dust which is assumed to be sifting down through the atmosphere as a result of the frictional destruction of smaller or larger meteorites which are constantly bombarding the earth There have been several instances in which matter, thought to be of this origin, was collected Two of the sources were the sea-bottom oozes and the arctic snows. Also, there was the case of Professor Maud Makemson, now of the department of astronomy, Vassar College, who collected dust in pans or on sheets placed on towers or other suitable locations The material was questionably identified as of cosmic origin

The writer has made many attempts to collect this material during the past ten years, but only recently has he met with success On the assumption that considerable portions of meteoritic matter would be magnetic, he, in September 1938, tried the experiment of collecting by means of a magnet, at the exits from down-spouts which carry off the water from roofs. This proved to be a fruitful source of a heavy, slaty-gray dust which gave a positive nickel reaction. Microscopically, the material was found to be composed of many irregular particles among which are found multitudes of minute spherical globules, many of which are highly magnetic, so much so that the majority of them constantly cluster together in aggregates of a dozen or more

The average diameter of those spheres measured was about 09 mm, but it is believed that the major portion of the smaller globules had been lost from this sample and that the average will finally be determined as considerably smaller.

The samples taken were from various types of roofs including wood shingles, composition shingles, slate, tile and galvanized iron Oxide scale was often found to contaminate the dust. This could be and was readily removed from the samples by reason of its strikingly different appearance

Our chemical tests were made by four independent authorities. Two spectroscopic analyses were made one of which was by Dr Arthur S King, of Mt. Wilson Observatory Nickel was prominent in all of the reports

Experiments have proven that there is a magnetic constituent of coal smoke which may pollute the collections made by our method, but the particles from this source are of a lighter color, a lower specific gravity, less magnetic and contain no nickel. Such pollution can also be avoided by collecting from roofs which are remote from the sources of coal smoke Our collections were made by the use of an alnico magnet supplied by the General Electric Laboratories. In order to prevent nickel contamination from the magnet it was wrapped in a rubber jacket while collecting.

Collecting from roofs has the dual advantage of benefiting by the constant catching and concentration of the fall and also permitting a crude measurement of the rate at which the material accumulates on a given area. Each shower or melting snowfall washes off the accumulation that has arrived since the last previous washing, so that regular collections after each shower supply us with quantitative data. All of our collections are admittedly very tentative as yet, but they indicate that the final results will be of

the order of several thousand grams per square mile annually. If figures of this order are finally proven correct they are quite revolutionary indeed when contrasted with statements in text books in astronomy and geology which allow for an increment of only 10 to 100 grams annually on a square mile of surface.

Much careful research yet remains to be done along the lines of refining the methods of collecting, of analyses and separation of meteoritic from terrestrial dust, of seasonal and geographic distribution of the fall, etc. Years must be devoted to the task, but the final results are of profound importance to astronomy and geology, as well as to meteorology and meteoritics

The questions naturally arise, if such quantities of meteoritic matter are arriving on the planet why should the soil not be very rich in nickel and why should not we be knee-deep in meteoritic dust The answer to the first is that nickel rapidly leaches out of oxidized meteorites, as proven by the writer [1] To the latter question we reply that the surface of the soil is so churned and altered by the ordinary forces of weathering that the most scrutinizing search would be necessary to find even a trace of a rain of spatial matter, even though in the course of a million years it might amount to a layer several inches thick A layer of about the thickness of ordinary paper would accumulate in a period of a thousand years according to our very tentative calculations.

The dust with which we are dealing has been collected by several methods other than that described. A vessel was anchored to a mast made fast to the top of a tree on a remote mountain top at an elevation of about 11,000 feet and left for seven months. Ice was melted from the surface of a mountain lake The rough bark of trees was searched by means of a magnetic device. A magnet was floated from a pilot balloon for six hours in a 20-mile wind over a snow-clad mountain For seven days air was sucked over powerful magnets by an electric fan on the top of a high tower In all cases the same kind of material was collected, but in immeasurably small quantities

We found by experiment that our nickel-containing dust is of high specific gravity and that it falls through the air at a rate of about 300 feet per minute. This clearly demonstrates that the most effective methods of collecting it must be devices which catch it in its descent and concentrate this catch It is here that the eave-trough functions rather efficiently.

[1] See *Amer. Min*, Vol. 23, No 8, August, 1938.

PHILANTHROPIC CONTRIBUTIONS IN 1939

THE record for the year throws no new light on the question as to whether the total annual amount of philanthropic contributions is likely to rise or fall. On the other hand, it does confirm the impression that the base of supply is steadily widening It is significant that a Masonic body in Ohio is contributing $50,000 a year for research in mental hygiene. It is significant also that the human as well as the economic problems of modern housing are being attacked by federal, state and municipal authorities, by two younger foundations, the Ford and the John B Pierce, as well as by certain of the older ones, and finally by real estate and insurance interests, notably by the Metropolitan Life Insurance Company, which is investing some $65,000,000 in a housing development in New York City.—*Report of the President of the Carnegie Corporation of New York.*

BOOKS ON SCIENCE FOR LAYMEN

CONSERVATIVE CONSERVATION[1]

THIS is a conservative book on conservation And in that statement there is more than meets the eye One of the interesting discrepancies of life and language in our time lies in the fact that many of the people whom we call conservatives have not yet become conservationists. This of course is because too many of them are trying to conserve a way of living which was one of the chief causes of the depletion of our natural resources The problem is to get them busy on conserving the physical basis of all wealth Otherwise, the things for which they now contend will soon have little meaning

The present volume is a good inventory of the assets we have to conserve It is attractive, clearly written and follows the prevailing pattern of approach This pattern is that of a separate attack on each phase of conservation if and when it begins to assume a pretty immediate economic importance

The book is sparing in its condemnation of past events—which is just as well since there is no point in chasing water over the dam It is equally sparing of suggestions regarding social and community readjustments which will have to be faced before we are through. Such suggestions do not always make palatable reading if one is trying to re-educate those whose cast of thought is conservative No school board is likely to buck at adopting this as a text, and certainly if a generation of young people becomes familiar with its contents, we shall be a long way ahead on the road towards a better America

Each of the four specialists has treated the problem with which he is professionally familiar In order, the four sections are · Soil and Water, Forests, Parks and Grazing Lands, Wildlife; and Mineral Resources A really surprising amount of information is compressed into each section The nature and extent of each resource group is set forth, and a good account of the manner of its depletion is given in each instance Technological measures for arresting this depletion are described, and some legislation recommended There is less offered in the way of remedy in the excellent section on "Mineral Resources" than in the others This is, after all, an extremely hot potato. If the author gets the facts before the American public he has probably done his share for the present

The section on "Wildlife" is in some ways the liveliest of the lot, not only because of its style and the nature of its material, but because of the glimpses of an ecological point of view which is too rare in other parts of the book For whatever else it may be, conservation is certainly applied ecology

The section on "Forests, Parks and Grazing Lands," like that on minerals, has its data well organized. This of course is in keeping with the alert, industrious and realistic tradition of American forestry. The problem of grazing is dealt with here, doubtless because the Forest Service happens to have been "one of the greatest herdsmen since Abraham" But one could wish, with grasslands originally occupying over 40 per cent of the nation's surface, that they might have received more extensive treatment than the arrangement of the book has allowed

The section on "Soils and Water" is essentially agricultural in its approach. It tends to emphasize the mineral rather than the biological aspects of the soil And it is more concerned with practical operations than with the broader problem of land use, which might very well have afforded the basis for a unifying treatment which is absent in the book. In fact, it may be questioned whether

[1] *Conservation in the United States* By A F Gustafson, H Ries, C H Guise and W J. Hamilton, Jr Illustrated $3 00 1939. Comstock Publishing Company.

the authors have not gone too far in their efforts to be practical, concrete and non-controversial, and to avoid seeming theoretical For there is, after all, a unifying theoretical basis for the whole problem of conservation. It can be expressed in a variety of idioms These range from the mathematical concepts of Haskell (*Ecology* 21 (1) . 1, 1940), through the operational terms of the student of plant and animal communities and the culture pattern concept of the anthropologist, to the dictum of the artist that an ugly landscape is a diseased landscape

It is of course essential that the American people have access to the accounting records of their capital wealth These are the dispassionately presented figures But accounting is a matter of relationship as well as record And it is more important than ever to-day that the numerous individuals and agencies interested in particular aspects of conservation—floods, water supply, fish and game, forestry, grasslands, minerals, soil and levels of human living—realize that they are all working on facets of the same problem That problem is the sane and permanent relation of man to the landscape of which he is part He has become a major geological influence and the custodian of evolution

The clear statement of a theory can, at times, be an exceedingly practical measure.

PAUL B SEARS

EFFECTS OF DIETARY DEFICIENCIES[1]

DR PRICE's thesis may be summarized in a few words Tooth decay is a result of civilization and is due to the fact that civilized man has discontinued using, in their native states, those foods which savage man had long ago established as requisite to normal body development. Modern methods of food purveyance have robbed us in great measure of two very important food elements, vitamins and minerals Modern nutritionists must compensate for this loss by food additions in concentrated form, but this replacement does not adequately take the place of those original foods which were provided by nature

To those who are versed in dietetics this may sound prosaic and self-evident. But the charm of Dr Price's book is found not in the proving of his thesis so much as in the description of his method He carries us into a high valley in the Swiss Alps where modern civilization has scarcely penetrated and compares the results of his dental examinations here with those in other parts of Switzerland where motor highways have been put through and the natives no longer depend primarily on rye bread, beef, lamb, cheese and other dairy products for their sustenance In succession he carries us to remote islands off the coast of Scotland; Eskimo habitations and North Canadian Indian villages, too remote from "store food" to be influenced thereby, Central Africa; Melanesian and Polynesian tribes scarcely in contact with the white man's commerce; Australian aborigines and remote Peruvian Indians in their mountain fastnesses In each locality he compares the dentition of those groups which have been scarcely touched by contact with civilization with those of the same races among whom commerce has resulted in some degree of change to the white man's diet, including white bread, canned foods, and the like In every instance he discovers deterioration in the teeth and, as a rule, underdevelopment of the jaw, palate and contiguous bones Abundant photographic illustrations provide confirmatory evidence.

An outstanding example was his study in one of the Pacific Islands Until the World War, copra was cheap and Island dwellers lived on native food. Suddenly

[1] *Nutrition and Physical Degeneration A Comparison of Primitive and Modern Diets and Their Effects* By Weston A Price Foreword by Ernest Albert Hooton 134 figures. 431 pp. $6.00. 1939. Paul B. Hoeber, Inc

the price of copra rose to four hundred dollars a ton. This was paid for in 90 per cent white flour and refined sugar and 10 per cent. cloth and clothing. Dental decay made its appearance for the first time. When, after the war, the price of copra dropped to four dollars per ton and the trading ships no longer called, tooth decay stopped

There is much in this book besides the foregoing, which some might consider self-evident. Dr. and Mrs. Price have been to out-of-the-way places, which the white man rarely reaches This was an essential part of their program The description of tribal customs and taboos makes the volume a travelogue of great interest not only to students of dietetics but to all whose interests include the habits and customs of mankind in all parts of the world

Although the volume may be read with profit there are points which are subject to criticism. Dr. Price has carefully studied the oral cavities of the inhabitants of those remote regions He is a dean among American dentists, and none would question his findings But in his conclusions he goes much farther than the observations warrant, attributing both physical and moral deterioration and demoralization of the white man to present-day dietary deficiencies. At a time when a Lombroso's stigmata of degeneracy are passing into the discard, he presents a new series of stigmata, summarized in under-development and mal-development of the bones of the middle part of the face He presents confirmatory evidence in his study of modern criminals, but very little in the way of comparison with non-criminals or normal controls. Although reason tells us that there may be much to what he says, his conclusions are not justified by the evidence presented. Unfortunately, Dr. Price presents his conclusions, as generalizations, in the introductory chapters As a consequence a critical reader is apt to become slightly dubious after the first few pages.

One who starts his reading at chapter three will discover a most interesting travelogue with a discussion of the effect of the modern dietary on tooth decay and certain facial deformities, which should be provocative of real concern. In the concluding chapters one will find generalizations which are at least food for thought.

WARREN T. VAUGHAN

ANIMAL LIFE IN WINTER[1]

IT is a lamentable fact that naturalists seem to prefer the cloistered library or fireside during the winter months and do not rouse from their lethargy until the first red-wings pronounce that spring is at hand. Then there ensues a mad scramble to make for the fields and woods, to study animals during their altogether too brief reproductive period. With the approach of cold weather outdoor science is soon forgotten and the field notebook, camera and collecting kits are laid aside until another spring

There is no longer reason for this winter lassitude. Dr Morgan's "Field Book of Animals in Winter" has opened an entire new vista, previously known to a privileged few. Her scholarly account of the winter habits of animals generally, from the sponge colonies of swift-flowing brooks to the dormant woodchuck in his subterranean chamber, should prove of interest to the professional biologist and the layman alike. No longer can one excuse himself from winter field work by stating that there is nothing to see nor study.

The volume sets forth in some detail the devices used for meeting the inhospitable winter season and how animals migrate, either from the tree-tops to the leaf mold below, or shun completely the snow and ice by retiring to more temperate climes. The subject of hibernation is treated adequately, and an able discussion is set forth on winter com-

[1] *Field Book of Animals in Winter.* By Ann Haven Morgan. 16mo. 283 illustrations. 4 colored plates. $3.50 1939. G. P. Putnam's Sons.

munities of land animals and the seasonal changes in fresh water and its animal inhabitants Nineteen chapters are devoted to the fresh-water sponges, hydras, flatworms and planarians, rotifers, bryozoans, annelids, leeches, crustaceans, insects (both land and aquatic) spiders, molluscs and the vertebrates The many illustrations from the author's camera and facile pen are guarantee enough that she knows the animals of which she writes so well

In a volume of this magnitude, errors obviously are inevitable; the wonder is that there are so few The author (p 365), quoting Benedict, states that woodchucks may actually gain weight during hibernation It has long been established that, *under natural conditions*, all hibernating mammals lose considerable weight On pages 25 and 427, the red squirrel is said to hibernate, although it is said not to hibernate on page 465 The latter statement is correct On page 431 we read that hay has been found in the winter burrows of woodchucks, thus implying that they store food, which is not true The star-nosed mole does not mate in November (page 442) but has a breeding season similar to that of other moles, in the spring *Sorex cinereus personatus* (p 443) should read *Sorex cinereus cinereus* The marten, like many other mustelids, exhibits delayed implantation and mates in late July or August, but never in January (page 453) The muskrat house is not "a dome of mud overlaid with cat-tail stems and weeds" (page 472), in fact, little mud is used in its construction Several plates in Chapter 25 should be credited to the *Journal of Mammalogy* and not the *American Journal of Mammalogy* While Cox has shown that the snowshoe hare emigrates, such movements are not comparable to the great lemming migrations of Europe (page 477) Mild winters are not particularly inducive to breeding, it is questionable whether cottontail rabbits breed the year round where winters are mild (page 478). But these are all minor errors, and do not detract in any measure from the value of this book Some might wish for a plate or two of tracks; a feature which would add to the interest of winter hikes

Every nature lover, whether he be a professional zoologist or school child, will profit from reading this book It should find a place in every school library

W J HAMILTON, JR

TREES AND MAN[1]

WHEN one realizes that the continents were carpeted and forested for millions of years with mosses and ferns, or fern-like vegetation, a number of speculations come to mind One of these is, what forms of animal life would now stalk the earth (or creep over its surface) if the seed plant had never evolved? Would the appearance of Man have been possible, or having taken his place with animal life, what would be the present status of Man if there were no fruit-bearing or wood-producing plants? How could Man have adapted himself to a life where only ferns or fern-like trees were the dominant vegetation? Certainly the entire physical, physiological, psychic and economic history of the organism known as Man and his present-day institutions would be vastly different if only these simple plants provided his food and materials

Pertinent to such a question one might speculate a little further and inquire into what Man's present status would be if only plants with seeds borne in cones (Gymnosperms) had evolved How different would be the food problems of Man to-day; our farm problems (if any), our trade agreements on foodstuffs; our diet, if we had no fruit-bearing plants (Angiosperms) nor the multitudinous substances obtained from the seeds of such plants (either directly or indirectly)

One of the achievements of Lamb's re-

[1] *Book of the Broadleaf Trees* By Frank H Lamb. Illustrated 367 pp $3 75 1939. W. W Norton and Company

cent book lies in the sharp realization brought to the reader of the absolute importance of broad-leafed Angiosperms in human affairs Described as a "treasury," this book quite meets all that is implied by the term In what one might call a Van Loon manner, the author has woven together such an amazing variety of information that the reader who naturally assumes that he is going to learn something of trees discovers that he is, at the same time, learning pertinent facts about geography, geological history, human customs and habits in distant parts of the earth, the qualities and uses of woods and the genealogy of trees All this and many other kinds of information are so well presented, integrated and developed that the account takes on the atmosphere of a plot Consequently, it is likely that when one reads the book from beginning to end a climax is expected—only to find that the drama of "Broadleafia" is far from complete and is a moving and unfinished story

The history is punctuated by well-chosen arboreal verse, which is very artistically used In fact, the book could be considered a good companion volume to the Sidney Lanier anthology, "Poems of Trees" Thus the work meets the interests of the botany student, the worker in woods, the student of history and economy, the poet and the general reader Figures, percentages and statistics there are a-plenty, but these are neatly used and serve only to make statements convincing and to help one realize in a factual way the enormous economic and sociological importance of trees The minutia, the innumerable details, the references to happenings in Australia, the distribution of a species in Oregon or the migration of trees from the Orient are also dealt with so as to impress the reader with the thoroughness with which Lamb has traveled, read and observed.

In the first chapter the author presents a clear, if much telescoped, picture of the origin and development of broad-leafed trees and their successful dominance (eventually) over the primitive and less adaptable evergreens (the conifers) A geological time chart or tree calendar assists in illuminating this picture and in tracing the broadleafed trees from *Caytonia* in the Jurassic through six epochs of geological time A map of the world inside the cover and another of North America alone help one to visualize the present distribution of the broadleaf forests (involving some fifty different species) While emphasis is placed on the woods of North America the scope of the book is definitely world-wide so that there is a chapter on "North American Broadleafia" and "Broadleafia Abroad" as well In the latter chapter the distribution of many kinds of trees is discussed somewhat historically, together with the environmental factors related to their distribution Also the importances to Man are consistently brought to the fore

In several chapters anecdotes and word pictures are sprinkled generously throughout in such a manner that the interest of the reader is never permitted to sag These features, together with many excellent photographs, make the book very graphic indeed A few trees such as walnut, beech and oak are given special attention and several chapters are devoted to these well-known and important members of the broadleaf forest

In a chapter entitled "Woodland Idyl" the reader is pleasantly and almost unconsciously taught some formal botany, interspersed with such vivid descriptions of life in rural America that many will experience a touch of nostalgia upon reading In a chapter on "Patrician Hardwoods" one of the most interesting sections describes the meaning of maples in the insignia and emblems of various peoples, their importance as ornamental trees or as sources of valuable wood and food, together with an account of the distribu-

tion and dispersal of a legion of species over the earth from Japan and China

Some bits selected at random from the book will serve to illustrate the great variety of lore included in this (if one may coin a word) philosylvanic treatment A sprig of elm is placed, even to-day, in the butter churn by European peasants to prevent the bewitching of cream—a rite descended from the tree worship practiced by pagan races The maple is called a sycamore in England because this tree was used in the early mystery plays on account of its being nearest in appearance to the sycamore scaled by Zacchaeus in Biblical tradition The English walnut is not English at all but came from Asia Minor via Italy and Southern Europe The Koala, or "Teddy Bear," which is the only animal that lives entirely on tree leaves and the only one which does not drink water, is a specific inhabitant of the eucalyptus tree in Australia Gumbo-limbo is a curious tree in Florida, the sap of which is used as a liniment and as a cure for gout Fifty billions of toothpicks are made from seven and a half million board feet of birch lumber

For pure esthetic enjoyment there is an Epilogue of verse and poetic prose Some readers may be disappointed in the brevity of the bibliography and in the fact that the index lists only the common names of the broadleaf trees

G W PRESCOTT

ESSAYS ON SCIENCE[1]

APPARENTLY the world is beginning to realize that there is a strange new force at work, one that perhaps should be both revered and feared It is called *science*, though the word is used in a great variety of meanings This recent awareness of the great importance of science has given rise to books on science from many points of view. "Science Marches On" is the latest

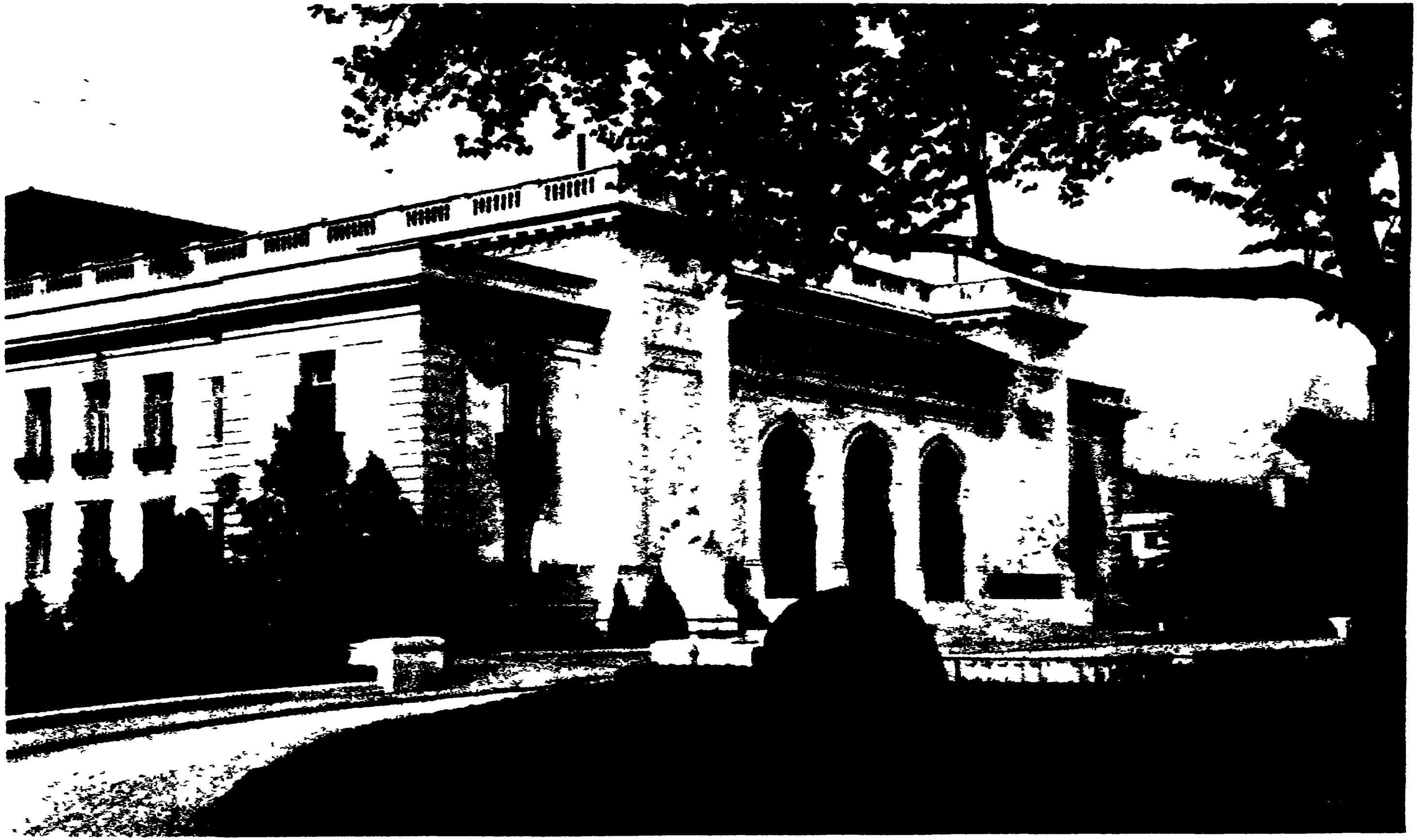
The author adopted a praiseworthy plan "to present science as a whole," presenting particular scientific advances as illustrations of general principles He regards the accounts of science by scientists as being "generally biased to an incredible degree," and he asserts that "the parts played in the acquisition of knowledge by the esthetic sense, by intuition, and by ethical motive, for instance" are "usually ignored and often violently denied" One can not but wonder what masters of science from Aristotle to Einstein the author has read

The book itself consists of an introductory chapter followed by nineteen chapters, each devoted to a single general topic, and a concluding semi-philosophical, but rather weak, chapter on "Where Is Science Going?"

The nineteen chapters on scientific subjects are well written and individually interesting, but they do not follow any easily discoverable plan For example, after an interesting chapter on the origin of written records, followed by one on fire, the author continues with an amazing mixture in "Earth's Fruits" In it he runs all the way from prehistoric use of metals to types of crystals, double refraction of light, polarization, interference figures, crystal analysis and lattice structure, and finally closes with a strange story of a polar continent "Arctis" and a theory of its relation to the formation of coal, asphalt and petroleum The chapters themselves, on such subjects as "The Origin of Life," "The Idea of Evolution," "The Fascination of Figures," "Pigeon-Holes of Knowledge," "The Mystery of Light," "The Miracle of Musical Sound" and "The Control of Force," illustrate the variety in the book and the lack of clear relationships among its parts.

F. R. M

[1] *Science Marches On* By Walter Shepherd. $3 00 420 pp December, 1939 Harcourt, Brace and Company



THE PAN AMERICAN UNION BUILDING—HEADQUARTERS OF THE CONGRESS

DEDICATED IN APRIL, 1910, AND FINANCED LARGELY BY MR ANDREW CARNEGIE, BUT ALSO BY APPROPRIATIONS FROM THE UNITED STATES AND LATIN AMERICAN COUNTRIES THIS BUILDING CONTAINS THE COLUMBUS MEMORIAL LIBRARY OF THE UNION

THE PROGRESS OF SCIENCE

EIGHTH AMERICAN SCIENTIFIC CONGRESS

La asociación de los pueblos americanos en un congreso científico es la mejor manera de crear entre ellos una sincera amistad—una amistad libre de toda sospecha Es a su vez la mejor manera de estimular el estudio de numerosos problemas que poseen un carácter peculiarmente americano.

Deberíamos tener presente que los principales políticos, economicos y sociales que han de predominar en el nuevo mundo, pueden implantarse unicamente después de estudiar el carácter nacional, el origen histórico, y les costumbres y tradiciones de los pueblos de este Continente

The association of the American peoples in a scientific congress is the best way of creating between them a sincere friendship free from all suspicions It is also the best way of furthering a study of numerous problems that possess a peculiarly American character

We should bear in mind that the political, economic and social principles which are to predominate in the New World can be implanted only after a study of the national character, the historical origin, the customs and traditions of the people of this continent

Eduardo Poirier.

This sentiment, so ably expressed at the First Pan American Scientific Congress held at Santiago de Chile in 1908, ever since has animated and given definite purpose to these meetings of scholars from all the Americas It is especially gratifying at the present time to realize that science in all its branches is able to play a part as a coordinating and stabilizing force among the twenty-one American republics And we in the United States should regard ourselves as especially fortunate in being privileged to act as hosts to the Eighth American Scientific Congress

The Eighth American Scientific Congress will be held in Washington, D C, from May 10 to 18, in response to invitations sent to the governments of the other American republics by President Franklin D Roosevelt In a letter to the Honorable Cordell Hull, Secretary of State, President Roosevelt wrote

> Our debt to the men and women of science defies computation The generous contributions which scholars and technicians have made to our twentieth century civilization have earned for them a position of influence and respect unparalleled in any other period of the world's history The path of the scientist and scholar is the path to peace and prosperity which lies open to all nations and all peoples . It is hardly necessary to delineate here the obvious benefits resulting from a meeting of these unselfish benefactors of mankind in an atmosphere of true fraternity such as the Eighth American Scientific Congress offers I sincerely hope that professional leaders in all of the Americas will avail themselves of this opportunity to share the friendship of their colleagues throughout the Hemisphere

In a letter to the Secretary of State expressing his deep appreciation of the action taken by the Government of the United States in convening the Eighth American Scientific Congress Dr Leo S Rowe, Director General of the Pan American Union, called attention to the fact that in April the Pan American Union observes the fiftieth anniversary of its founding at the First International Conference of American States, which met in Washington in 1889–90, and he wrote that it is especially gratifying that the scientific congress will be held as a part of the program that will commemorate this significant date in the history of the Union, and in the history of inter-American relations in general

The Eighth American Scientific Congress will be held under the chairmanship of the Honorable Sumner Welles, Under Secretary of State, with Dr Warren Kelchner, chief, Division of International Conferences, Department of State, and Vice Chairman, and Dr Alexander Wetmore, Assistant Secretary, Smithsonian Institution, as Secretary General

The congress is divided into eleven

sections, each of which has as its chairman a member of the organizing committee. The sections are Anthropology, Biology, Geology, Agriculture and Conservation, Public Health and Medicine, Physics and Chemistry, Statistics, History and Geography, International Law, Public Law and Jurisprudence, Economics and Sociology, Education. Each of these sections embraces a broad field, in many cases broader than the title would indicate, and between them they cover the entire field of science.

The congress will be formally opened by President Roosevelt on the evening of Friday, May 10, at the Pan American Union. Registration and the preliminary organization of the sections will occupy the entire first day of the congress, and the definitive organization of all sections will be completed on Saturday morning. A trip to Mount Vernon has been arranged for Saturday afternoon, and in the evening there will be an official reception at the Pan American Union. A motor trip through the springtime countryside of Virginia to the beautiful Caverns of Luray will feature the program for Sunday. The first plenary session of the congress will take place on Monday, followed by the official luncheon tendered by the United States Government to the governmental delegates of the other American republics. The afternoon will be devoted to the business of the various sections. Tuesday will be devoted entirely to meetings of the sections, with a special symphony concert in the evening. Wednesday morning and early afternoon will be

THE PATIO OF THE PAN AMERICAN UNION BUILDING
DESIGNED AFTER THE TYPICAL LATIN AMERICAN PATIO, WITH A COVERED PROMENADE AND OPEN TO THE SKY AT THE TOP. A SLIDING ROOF, HOWEVER, CLOSES OVER THE PATIO DURING BAD WEATHER. A MAYAN FOUNTAIN, DESIGNED BY MRS. HARRY PAYNE WHITNEY, PLAYS IN THE CENTER OF THE PATIO.

HALL OF THE AMERICAS IN THE PAN AMERICAN UNION BUILDING
THE ROOM ACCOMMODATES BETWEEN 800 AND 900 PERSONS WHEN USED AS AN AUDITORIUM. THE WORD "PAX" INSCRIBED IN THE FOUR CORNERS OF THE ROOM SYMBOLIZES ONE OF THE IDEALS OF THE UNION

devoted to congress matters. Later in the afternoon the delegates will be guests at a garden party in their honor. Thursday, after a full day of sectional proceedings, there will be held the official banquet of the congress, at which the official delegates will be the guests of the United States Government. The final meetings of the sections will be held on Friday morning, and the final plenary session of the congress will take place the same afternoon. Later in the same afternoon the delegates will leave by river steamer for Old Point Comfort, whence they will proceed by way of Jamestown and Yorktown to Williamsburg to inspect the restorations. Tuesday will be Eighth American Scientific Congress Day at the New York World's Fair.

The Eighth American Scientific Congress is the culmination of an interesting series of events. It was at Buenos Aires, Argentina, on the occasion of the celebration of the Silver Jubilee of the Argentine Scientific Society in 1898 that the first scientific congress of international scope in the Western Hemisphere was held. This meeting achieved such eminent success and excited such favorable attention throughout the South American republics that before adjournment a second congress was planned, to meet at Montevideo three years later. This second Latin-American Scientific Congress convened at Montevideo in 1901, present were 48 official delegates, 79 delegates of scientific organizations and 749 affiliated members. The third Latin-American Scientific Congress was

held at Rio de Janeiro in 1905, the attendance being about 800

At the closing session of the congress in Rio de Janeiro a resolution was adopted to hold the fourth Latin-American Congress at Santiago de Chile The congress initiated a significant departure when it stated that the agenda for the fourth congress should include matters of a distinctly inter-American nature The meeting at Santiago de Chile in 1908 thus assumed a new and comprehensive character Whereas at the three previous meetings there had been included only Latin-American delegates, the Government of Chile enlarged this basis of representation so as to include representatives from all the American republics, and at the same time the title "First Pan American Scientific Congress" was given to this meeting There was now manifested a new orientation of the subjects proposed for discussion For the first time a definite effort was made to limit the discussion to matters of Pan American interest, particularly those concerned with the social, political and economic relations peculiar to the Western Hemisphere

The second Pan American Congress was held in Washington in 1915 with more than 2,500 persons participating, including almost 100 official delegates from the twenty Latin-American governments, as well as 130 delegates from the scientific societies and institutions of Latin America The third Pan American Scientific Congress was held in Lima, Peru, in 1924, and the fourth at Mexico City in 1935 The present congress is the fifth Pan American Scientific Congress, or the Eighth American Scientific Congress

Austin H Clark

SESQUICENTENNIAL OF AMERICAN PATENT SYSTEM

This year—1940—marks the one hundred and fiftieth anniversary of the enactment of the first United States patent law On April 10, 1790, President George Washington signed the bill from which the modern American Patent System has gradually evolved Three years earlier, the Constitutional Convention had given Congress the power "to promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries "

When the delegates from the various states met in Philadelphia in 1787 to frame the Constitution of the United States they soon became aware of the need for giving some form of protection to authors and inventors under the new government Although the delegates, like other Americans of that time, were strongly opposed to monopolies of the sort granted by European monarchs, they voiced little objection to the principle of granting limited monopolies to inventors in the form of patents The delegates fully appreciated that some type of encouragement was essential to promote inventive genius, and they were equally aware of the resulting benefit to society when such encouragement is given It is not surprising that they adopted unanimously the Constitutional clause giving Congress the power to promote the useful arts

Before 1790 our colonies and our states had issued patents The existence of many different rules concerning patents in the various states and colonies was—to say the least—confusing An inventor might obtain a patent in one state and be unable to secure it in another In each state he would have to make special application to the legislature, as there were no general laws concerning the granting of patents

Soon after the first Congress met in New York City on March 4, 1789, it was besieged with petitions by inventors and

authors—each seeking special acts of Congress granting them exclusive rights It became evident that neither Congress nor the inventors could be burdened with the uncertainty of a special legislative act in each case, and that a general law providing for patents for inventions was necessary The first session of the Congress, however, passed without any final action

Soon after the second session of Congress met, President Washington addressed the members, pointing out the necessity of their giving effectual encouragement to the exertion of skill and genius in producing new and useful inventions Congress reacted quickly to the President's suggestion and appointed a committee to prepare a patent bill By April 10, 1790, three months after Washington's address, the bill had been drawn up, amended, passed and approved

When the first patent laws went into effect in April, 1790, this nation of six million was almost entirely dependent upon agriculture for its existence Industry played but a small role in the economic life of the country To-day, a hundred and fifty years later, the population has increased to a hundred and thirty million and the economic picture has completely changed To-day, America is essentially an industrial nation Unquestionably there is a direct relation between America's industrial development and her Patent System—the more than two million patents issued in the intervening years bear testimony to that relation

At first the number of patents issued by this country was small During the first year the patent laws were in effect a mere three patents were granted By 1836 less than 10,000 patents had been issued—yet among these were a number

OFFICIAL SEAL OF THE U S PATENT OFFICE
SYMBOLIZING AMERICA, AGRICULTURE AND INDUSTRY

To the Commissioner of Patents.

The Petition of Abraham Lincoln, of Springfield in the county of Sangamon & State of Illinois

Respectfully represents.

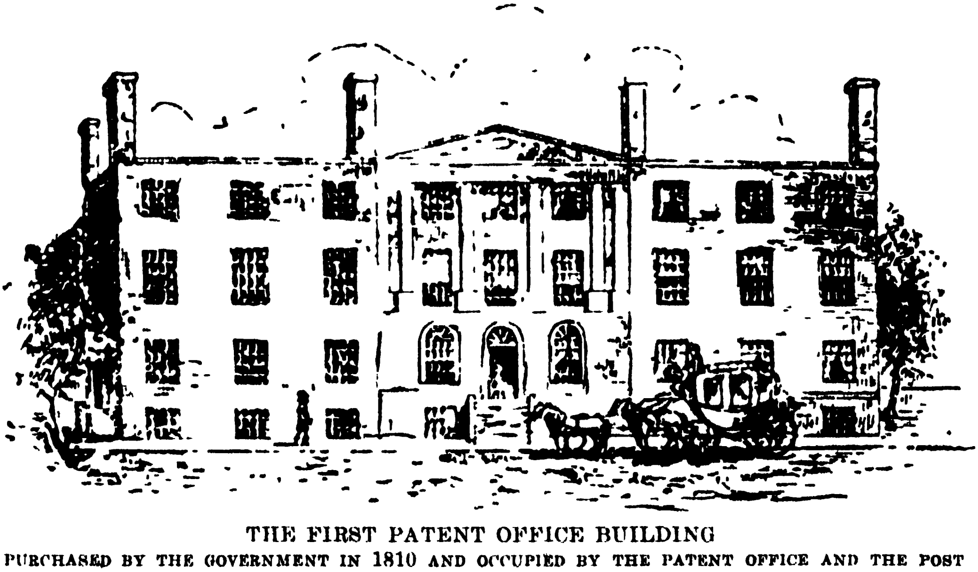
That your petitioner has invented, a new and improved manner of combining adjustable buoyant chambers with steam boats or other vessels which has not, as he verily believes been heretofore used or known, and that he is desirous that Letters Patent of the United States may be granted to him therefor, securing to him and to his legal representatives, the exclusive right of making and using, and of vending to others the privilege to make or use, the same, agreeably to the provisions of the Acts of Congress in that case made and provided, he having paid thirty dollars into the Treasury of the United States, and complied with other provisions of the said Acts.

And he hereby authorises and empowers his Agent and Attorney, Z. C. Robbins, to alter or modify the within specification and claim as he may deem expedient, and to receive his patent; and also to receive back any moneys which he may be entitled to withdraw, and to receipt for the same

A. Lincoln.

A PATENT APPLICATION OF ABRAHAM LINCOLN FILED ON MARCH 10, 1849

THE FORMER PRESIDENT WAS GRANTED A PATENT FOR AN INGENIOUS ARRANGEMENT FOR ENABLING OVERLOADED VESSELS TO PASS THROUGH SHALLOW WATER WITHOUT DISCHARGING THEIR CARGO BY A SYSTEM OF SLIDING SHAFTS, ROPES AND PULLEYS, CHAMBERS COMPOSED OF INDIA RUBBER CLOTH ARE LOWERED INTO THE WATER ALONG THE SIDES OF THE SHIPS, AND INFLATED



THE FIRST PATENT OFFICE BUILDING

PURCHASED BY THE GOVERNMENT IN 1810 AND OCCUPIED BY THE PATENT OFFICE AND THE POST OFFICE, UNTIL IT BURNED IN 1836, DESTROYING 7,000 MODELS IT WAS THE ONLY PUBLIC BUILDING NOT BURNED BY THE BRITISH IN 1814 THE BUILDING WAS CONSTRUCTED IN 1793 AND WAS KNOWN AS THE FIRST "FORMAL PLAYHOUSE" IN WASHINGTON IT HOUSED THE UNITED STATES THEATER

which were to have a vital bearing on our industrial advance As time went on the number of patents granted increased at a surprisingly rapid rate, and in the last thirty-nine years over a million and a half have been granted Last year alone over 49,000 patents were issued The Patent Office staff, which originally consisted of an examiner and three or four clerks, to-day numbers 1,350, of whom 700 are highly trained, scientific experts in the various fields of mechanical, chemical and industrial knowledge To accommodate all these workers and its equipment the Patent Office requires over eight acres of floor space, occupying one third of the mammoth Department of Commerce building, reputedly one of the largest office buildings in the world

The purpose of a patent, as envisaged by the framers of our patent laws, was to grant a reward for the invention or discovery of something new, something before unknown, something added to the sum total of human knowledge The patent not only rewards the inventor, far more important, it encourages him to invent, and once he has been granted a patent the whole world becomes informed of his discovery or improvement The world can not, without his consent, use the discovery or improvement for seventeen years, but thereafter the public has the full benefit of the device, whose secret might never have been revealed except through the Patent System

Doubtless some of the ancient civilizations, such as those of Egypt, Assyria and China, produced many useful inventions, capable of higher development and wider adaptation These inventions were lost to those people, however, and remain unknown to us because they had no patent system for perpetuating the discoveries of each succeeding generation Our system has preserved the earliest of the inventions made by our own people and those of other lands, and has initiated a process of industrial "evolution" From the first and simplest products of inventive genius more complex and efficient mechanisms and methods have been developed Every successive improvement and advancement has made still further progress imperative and inevitable The automobile and the airplane were but crude contrivances in their beginnings Their inventors and others who have followed them, however, devised additions to the capacity, the safety and the speed of these new carriers Many of us remember how the automobile acquired, one by one, the accessories that have come to be necessities of its equipment—pneumatic tires, self-starter, hydraulic brakes, electric lamps, etc

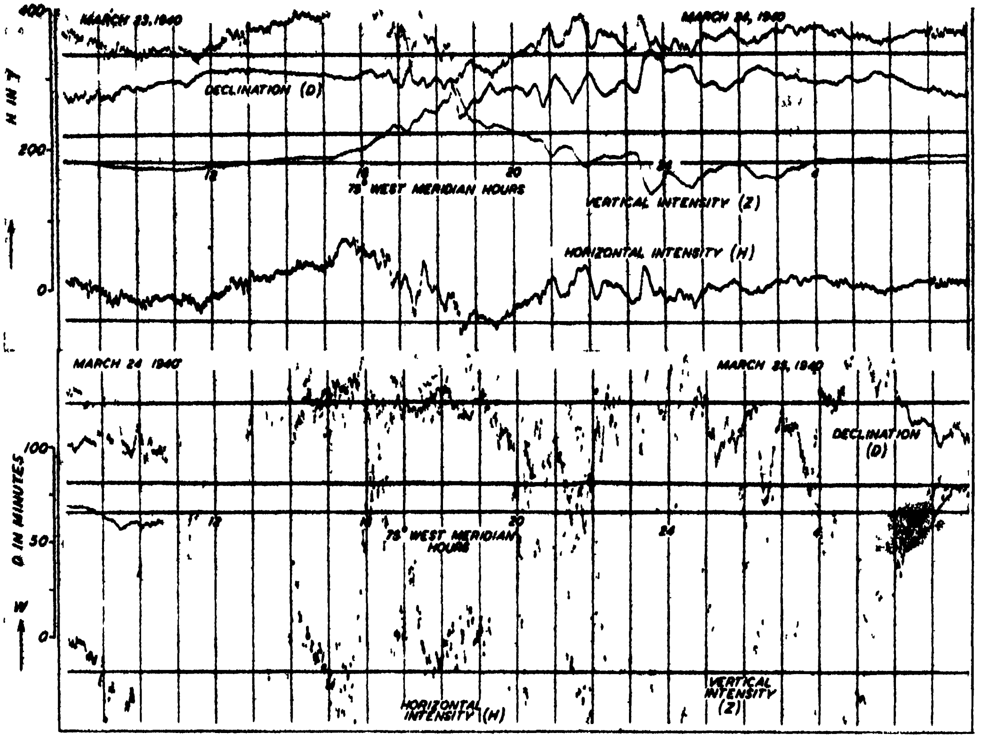
The American patent system has inspired inventions that have served the causes of science, art, education and better living It gives promise of further and greater benefactions In these troubled times in which we live we may be particularly grateful to a system which has made and kept this country stronger than any in the world, and thus able to resist any assault on its institutions and its form of government.

CONWAY P COE,
Commissioner

U S PATENT OFFICE

THE GREAT MAGNETIC STORM

THE greatest magnetic storm of the present sunspot-cycle occurred on Easter Sunday, March 24 Apart from the scientific interest of this event to students of geomagnetism, the storm derived much attention because of its effects on the elaborate electrical systems of our modern civilization—service by both telegraph and cable was seriously impaired, high-frequency radio communication over long distances was completely blocked out, and even electric power-systems were affected Because of the wide-spread popular, technical



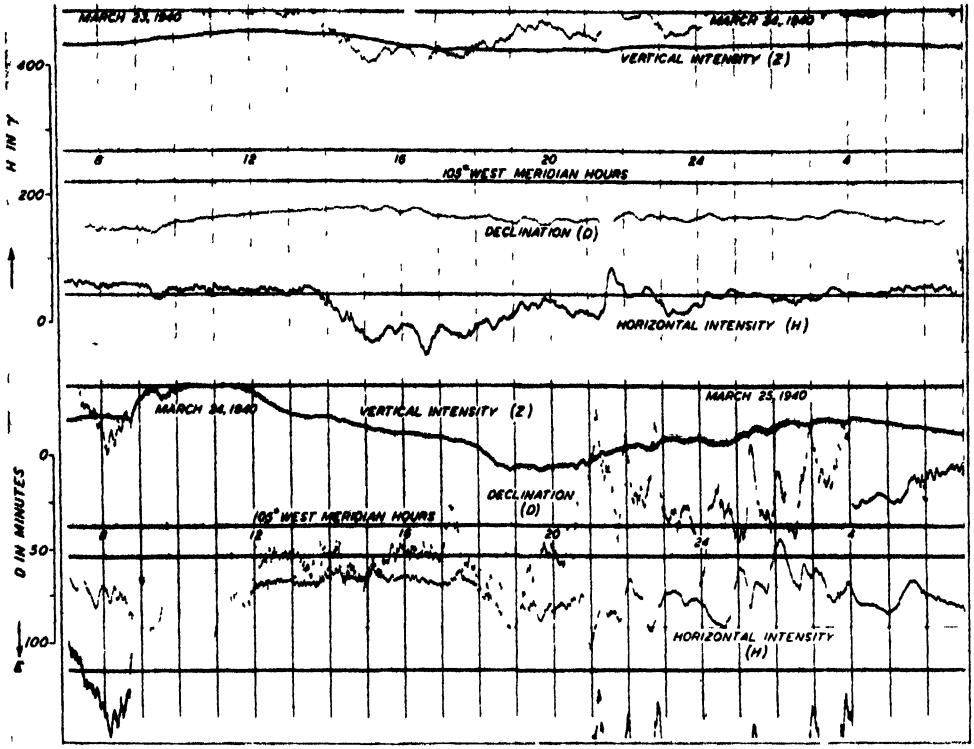
RECORDS OF THE MAGNETIC STORM FROM CHELTENHAM, MARYLAND

MADE AT THE U S COAST AND GEODETIC SURVEY OBSERVATORY, MARCH 23–25, 1940 THE THREE ELEMENTS OF THE EARTH'S MAGNETISM—DECLINATION, VERTICAL INTENSITY AND HORIZONTAL INTENSITY—ARE GRAPHICALLY RECORDED BY LINES UPON PHOTOGRAPHIC PAPER MOVEMENTS UP AND DOWN THE PAPER INDICATE DEPARTURES FROM NORMAL VALUES SOME MAGNETIC DISTURBANCE IS REVEALED ON ALL DAYS REPRESENTED THE GREAT STORM BEGINS AT 8^h 50^m, MARCH 24 MOVEMENTS WERE SO VIOLENT AROUND 12^h, MARCH 24, THAT FLUCTUATIONS ARE SCARCELY DECIPHERABLE ON THE ORIGINAL RECORD.

and scientific interest aroused by this storm a brief account of authenticated events associated with it has been prepared

Magnetic records from the Coast and Geodetic Survey Observatory at Cheltenham, Maryland, show that the storm began at 8^h 50^m, Eastern Standard Time At 10^h 45^m an interval of unusual violence began, reached its maximum intensity about 12^h, and continued until about 14^h. A high degree of magnetic activity persisted until about 9^h on the following day, March 25 Variations of 1,100 gammas (one gamma equals 0 00001 gauss) in vertical magnetic intensity and 850 gammas in horizontal magnetic intensity were recorded Since the normal horizontal intensity at Cheltenham is about 18,000 gammas, this represents a fluctuation of nearly 5 per cent in that component At the Niemegk Observatory near Potsdam, Germany, the ranges were about 2,000 gammas in the vertical and horizontal components of magnetic force, representing more than a 10 per cent fluctuation in the latter component Unusual displays of the aurora borealis were seen on the night of March 24, some visible even as far south as Tucson, Arizona The storm was followed by two more of much less intensity on March 29–30 and on March 30–31

The storm was associated with the passage of a moderately large active



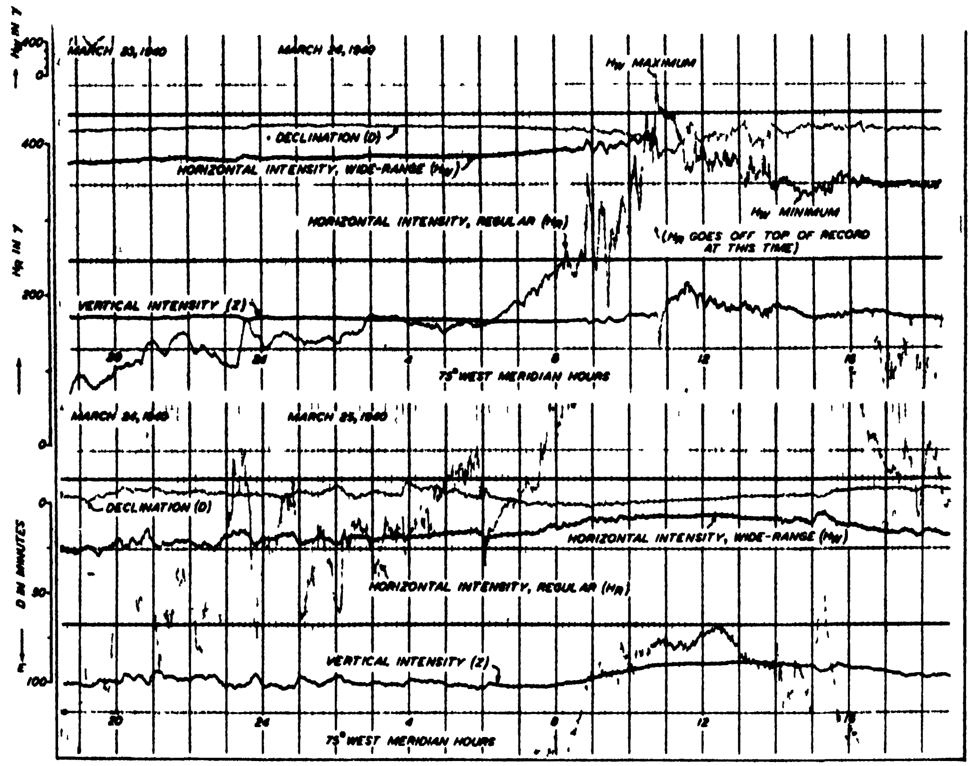
RECORDS OF THE MAGNETIC STORM FROM TUCSON, ARIZONA

MADE AT THE U. S. COAST AND GEODETIC SURVEY OBSERVATORY, MARCH 23–25, 1940. THE SIMULTANEITY OF MAGNETIC DISTURBANCE IS REVEALED BY COMPARISON OF THESE RECORDS WITH THOSE OF CHELTENHAM. BASIC FEATURES ARE REVEALED AT BOTH OBSERVATORIES MODIFIED BY LOCAL DIFFERENCES.

group of sunspots across the central disk of the sun. Although the sun showed a number of groups of spots at the time the storm occurred, the visible solar activity was not unusually great.

High-frequency radio communication was so severely affected that transatlantic channels were useless for the rest of the day after the beginning of the storm. Europe and America were practically isolated as far as communication was concerned and news broadcasters were severely taxed to find material on which to base comments on the European situation. Scheduled re-broadcasts of programs originating in Europe had to be cancelled and makeshift substitutions offered the audience—a circumstance which made the public more conscious of magnetic storms than it had ever been before. The day was the poorest on record for transatlantic radio communication.

From about $9^h\ 45^m$ until 15^h grounded telegraph lines were rendered useless because of intense earth-currents induced by the violent magnetic fluctuations. Potentials as great as six volts per mile were induced at times, fluctuations of 1,600 volts were observed on the 140-mile Western Union telegraph line between New York and Binghamton. However, communication by wire was still possible by use of "all-metallic" circuits, that is, those in which both the outgoing and incoming current is carried by wires rather than using the earth as one conductor. Under these conditions the earth-currents flowing in one wire are neutralized by those flowing in another



RECORDS OF THE MAGNETIC STORM FROM CARNEGIE OBSERVATORY IN PERU

MARCH 23–25, 1940. THE RECORDS AT THIS OBSERVATORY (ELEVATION 11,000 FEET) OBTAINED NEAR THE MAGNETIC EQUATOR—IN GEOGRAPHIC LATITUDE 12° SOUTH—EXHIBIT THE EQUATORIAL MANIFESTATIONS OF THE STORM. PERTURBATIONS WERE SO VIOLENT THAT THE ORDINARY RECORD OF HORIZONTAL INTENSITY WAS LOST, BUT A COMPLETE REPRESENTATION OF THE VARIATIONS WAS OBTAINED BY THE WIDE-RANGE RECORD. A TOTAL CHANGE OF 1,400 GAMMAS WAS RECORDED, NEARLY 5 PER CENT OF THE TOTAL INTENSITY OF THE EARTH'S FIELD AT THIS STATION. THIS IS THE GREATEST FLUCTUATION EVER RECORDED IN EQUATORIAL REGIONS.

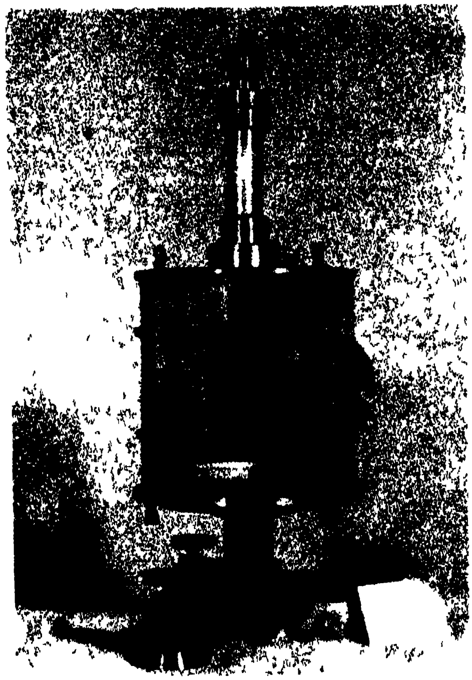
Such conditions seriously handicap telegraph companies, since twice as many wires are required to carry the same traffic as when grounded circuits are used.

The most striking manifestation of the storm was its effect on electric power-lines. Most power-engineers (and magneticians, too, up to the present) have been disinclined to believe that magnetic storms could have any appreciable effects on electric power-circuits. However, here are some facts. At about 11ʰ 45ᵐ the period of most violent magnetic fluctuations began and continued for about an hour. At 11ʰ 48ᵐ the Consolidated Edison Company of New York experienced a dip of about 1,500 volts on the 27-kilovolt busses at the Hudson Avenue Station in Brooklyn and also at the Hell Gate and Sherman Creek stations in the Bronx, the disturbance continuing for an hour or more. At 11ʰ 48ᵐ protective relays on two transformers of the Pennsylvania Power and Light Company were operated, the effects continuing until 12ʰ 45ᵐ. At 11ʰ 49ᵐ protective relays at a station of the Hydro-Electric Power Commission of Ontario were operated with subsequent loss of generation at that station. None of these systems was tied in to either of the other.

In view of the close coincidence of these independent but similar events

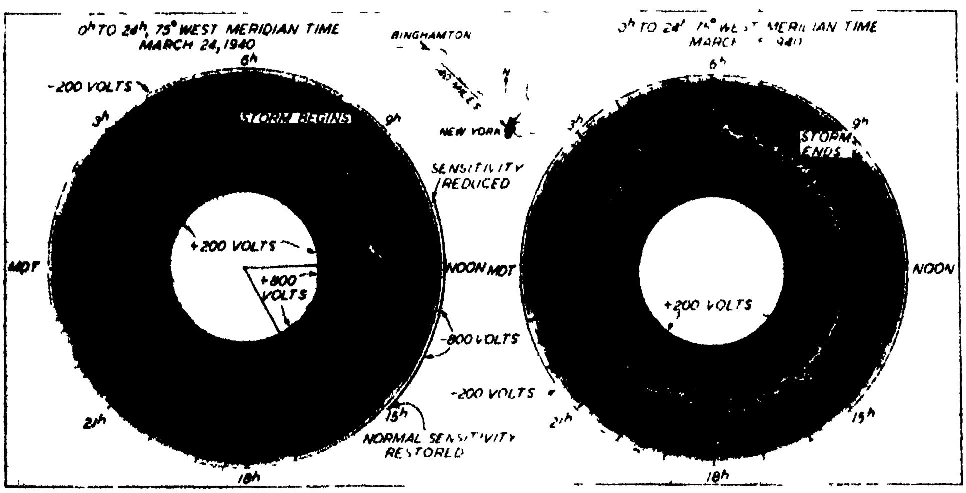
there appears little room to doubt their cosmical origin Skeptics may still believe that these effects were due to equipment failure, but the preponderance of evidence indicates that they were due to natural causes beyond human control As far as we have been able to ascertain no such effects have ever been reported before

Our knowledge of great magnetic storms is limited They occur at rare intervals, although several storms of unusual violence have appeared during the present sunspot-cycle Because of their rarity, students of geomagnetism have focused attention on observing and studying the lesser fluctuations of the earth's magnetism, and magnetic instruments have been adjusted to so high a sensitivity that perfect records of great magnetic storms are obtained at only a few observatories Because of their effects on our complex systems of electrification, interest in these storms is growing and additional equipment for faithfully recording them is being installed



A NEW INDUCTION-VARIOMETER

DEVELOPED AT THE CARNEGIE INSTITUTION OF WASHINGTON TO MEASURE VARIATIONS IN VERTICAL MAGNETIC INTENSITY



Courtesy Western Union Telegraph Company

EARTH-POTENTIALS BETWEEN NEW YORK CITY AND BINGHAMTON, N Y

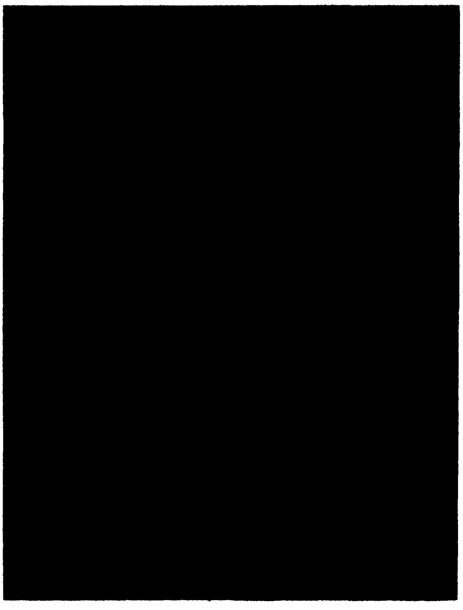
DURING STORM OF MARCH 24, 1940 RECORD TO LEFT WAS STARTED AT MIDNIGHT MARCH 23 AND AFTER COMPLETING THE CIRCLE ENDS AT THE STARTING POINT AT MIDNIGHT MARCH 24 IT REVEALS UNUSUAL DEVELOPMENTS OF POTENTIAL AT ONSET OF STORM, AT 10^h 45^m POTENTIALS BECAME SO GREAT THAT SENSITIVITY OF VOLTMETER HAD TO BE REDUCED, NOTE RECORD AROUND NOON OF FLUCTUATIONS FROM − 800 TO + 800 VOLTS THE RECORD ON THE RIGHT WAS STARTED AT MIDNIGHT ON MARCH 24, AND AFTER COMPLETING THE CIRCLE ENDS AT MIDNIGHT MARCH 25

Was this the greatest magnetic storm ever recorded? The answer to this question must await examination of magnetic records from many parts of the earth because the aspects of magnetic storms change from place to place. Considering only the reported range of variation this storm was not much greater than the one which occurred on April 16, 1938, but the duration of that storm was much less. The recent storm did not last as long as the one which occurred in May, 1921, but the latter did not produce as great fluctuations. However, when the final account is taken it seems likely that, considering both intensity and duration, the great storm of last month, which made front-page headlines all over the country, will appear as the greatest magnetic disturbance which has ever been recorded.

J. A. Fleming, *Director*
Department of Terrestrial Magnetism,
Carnegie Institution of Washington

ANNULAR ECLIPSE OF THE SUN

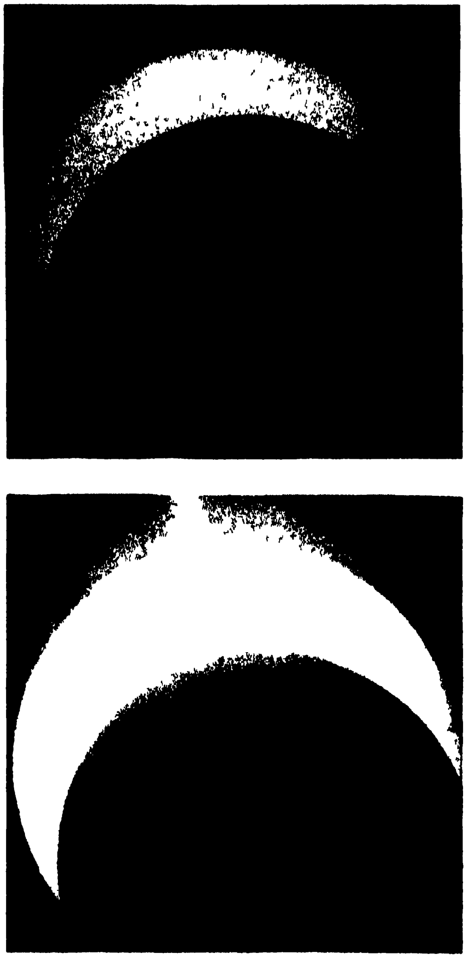
The Hayden Planetarium-Longines Eclipse Expedition successfully photographed the annular eclipse of April 7. Photographs were made from two stations, one on the roof of the Barnett National Bank Building in the heart of Jacksonville, Florida, the other from an



Charles H. Coles

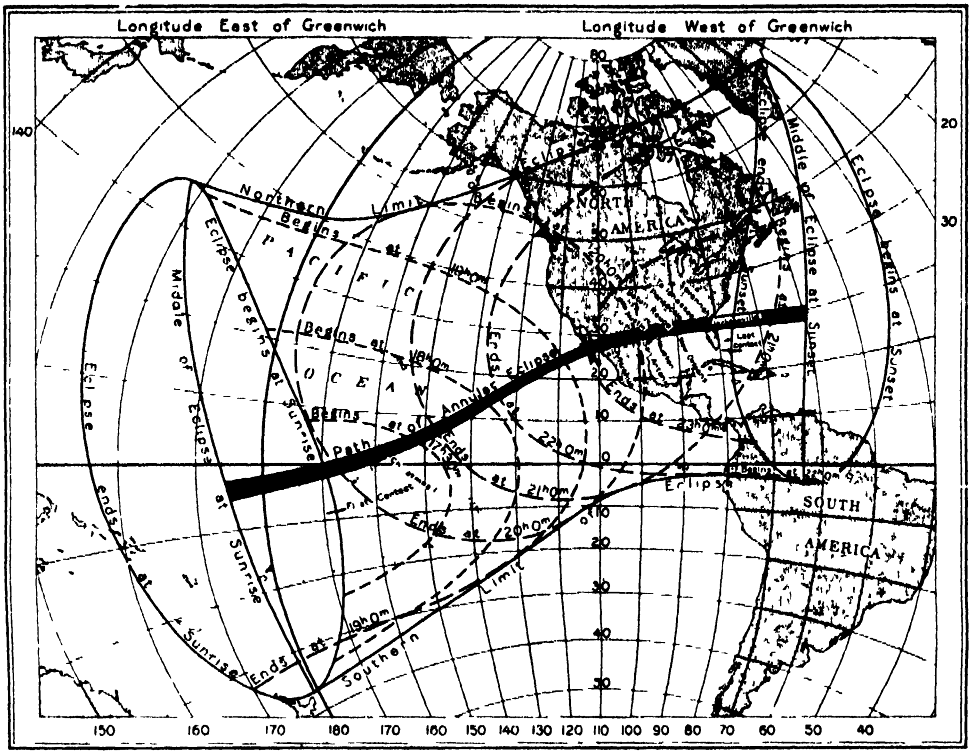
THE ECLIPSE FROM AN AIRPLANE

APRIL 7, 1940, ABOUT 40 MILES NORTH OF JACKSONVILLE, FLORIDA, AT AN ELEVATION OF 16,200 FEET. THE UNIFORM THICKNESS OF THE RING OF SUNLIGHT INDICATES THAT THE PICTURE WAS MADE FROM THE MIDDLE OF THE PATH



Wayne M. Faunce

PARTIAL PHASES OF THE ECLIPSE, JACKSONVILLE, FLORIDA



THE PATH OF THE ANNULAR ECLIPSE, APRIL 7

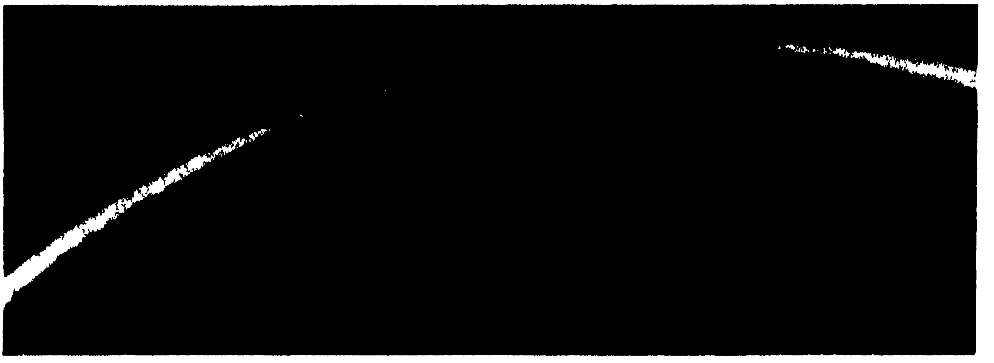
THE HOURS OF BEGINNING AND ENDING ARE EXPRESSED IN UNIVERSAL TIME OR GREENWICH CIVIL TIME

Eastern Air Lines Silverliner. A two-way description between the observation stations was broadcast over the radio.

At the ground station, Mr. Wayne M. Faunce, of the American Museum of Natural History, made a series of photographs with a 4-inch telescope attached to a Graflex camera. He secured pictures of the partial and annular phases. What is more important, one exposure showed Baily's Beads. We are likely to associate this phenomenon with total eclipses only. It is not generally known that Baily discovered this breaking down of the sun's light into a series of points at an annular eclipse in 1836. Baily's Beads were not observed visually by either those on the ground or those in the plane. No trace of either solar or corona prominences was seen.

The sky was partly overcast by broken cumulus clouds at a low level and a layer of thin clouds the top of which was at an elevation of about 35,000 feet. From the ground the sun was not continually visible but was sufficiently so to observe all phases of the two-hour-and-a-half period when the sun was eclipsed. The first contact was made at about 3:39 P.M., E.S.T., and the second contact at about 5:05 P.M. The annular phase lasted until about 5:10 P.M., the last contact being at 6:12 P.M.

The plane took off at 3:50 from the Jacksonville Airport. Representing the Hayden Planetarium were Mr. Charles H. Coles, photographer, and the writer as observer to broadcast. The plane climbed quickly through the broken clouds and to an elevation where the clouds above were so thin that they did not obscure the sun sufficiently to make observing difficult. By this time the moon had cut the sun down to a rather



Wayne M Faunce

A SECTION OF THE CRESCENT SHOWING BAILY'S BEADS

THE BRILLIANT SPOTS ARE PRODUCED WHEN THE MOUNTAINS COMPLETELY COVER THE SUN'S DISC, ALLOWING THE SUNLIGHT TO REACH THE EARTH THROUGH THE VALLEYS ON THE MOON

thin crescent It was somewhat surprising that even though the area of the sun was diminishing rapidly, the light did not seem to fade in the same proportion The clouds below were pearly gray with tints of pastel shades like the inside of a shell Around the horizon a rim of darkness was noticeable, apparently heavier cloud or shadow Above, the sky was a vague gray, uniform in tone It might have come from a change in color in the sky light or merely from clouds

Even when the annular phase was in progress with 86 per cent of the sun's area covered, the light was bright, giving the impression of a cloudy day with no particular color to the scene

During the annular phase and once afterward beautiful sun dogs were seen They were brightly colored, and it may be more than a coincidence that Mr Coles saw the same thing in Peru in 1937 when we observed the total eclipse from the top of the Andes, at an elevation of nearly 15,000 feet

Mr Coles made several pictures of the various phases with a 20-inch Fairchild aerial camera

The broadcast was marred by static and there was some difficulty maintaining contact with members of the other party on the ground and hearing them Perhaps the expedition studying short wave problems in Texas may be interested in our troubles

The Army Air Corps was also in Jacksonville and one of the new flying fortresses under the command of Major George W Goddard flew to about 38,000 feet and photographed the eclipse with a 60-inch aerial camera

A group of amateurs under the auspices of the Amateur Astronomers' Association of the Hayden Planetarium observed from St Augustine and a few from a charted plane out of Jacksonville

Despite the uncertainty of the weather before (and even during) the eclipse, things seemed to work out satisfactorily

My good friend, Dr John A Miller, who has chased eclipses all over the world, admits that no party ever returns completely satisfied This, perhaps is the incentive that leads one to the next eclipse

WILLIAM H BARTON, JR,
Executive Director
THE HAYDEN PLANETARIUM

THE SCIENTIFIC MONTHLY

JUNE, 1940

THE SOCIO-BIOLOGY OF MAN

By Dr. M. F. ASHLEY-MONTAGU

DEPARTMENT OF ANATOMY, THE HAHNEMANN MEDICAL COLLEGE AND HOSPITAL, PHILADELPHIA, PA.

WHAT is man as a biological being? What is man as a social being? What is man regarded as a function of both a biological and a social structure in interaction? These are the questions to which I shall attempt to return an answer. I propose to make no vague generalizations concerning the social and biological functions of human beings, but rather to attempt to relate the more fundamental of man's biological and social functions—concerning which reliable knowledge is available—to the world in which human beings exist at the present time; to indicate what the nature of those functions is, to point out how they have been understood and formed up to the present time, and finally, to suggest the nature of the principles which must be recognized if "Nature's sole mistake," as one unsympathetic philosopher has termed man, is to be turned into a success.

In the study of any organism it is always desirable to remember that the organism exists as a whole, and not merely as a series of parts which may be studied in dissociation from one another in atomistic fashion—as if such parts had any meaning apart from their relation to the whole organism. Yet this is a principle which has often been forgotten or neglected by numerous investigators in the pursuit of their studies, and its neglect has been the occasion of much confusion in scientific thought. Nowhere is the confusion thus engendered more apparent than in the fields of study relating to man in society. An instance of this, with which many will be familiar, is the practice of drawing inferences concerning the native ability of individuals on the basis of ratings derived from intelligence tests without taking into consideration the very necessary factors of the social and economic history of the individuals tested in this way. Or to quote another instance, there is the oft-repeated assertion that so-called primitive peoples are mentally inferior to ourselves because they have not developed a culture which can compare with ours. These are typical examples of inferences which are drawn from particular aspects of phenomena without any reference to the framework as a whole of which they form a part. When the whole, in such connections, is considered and understood, the real significance of the integrated part becomes unequivocally clear; and that significance is very different from that which is attributed to the part when it is not so considered in relation to the whole.

So, here we shall take mankind as a whole for our province, and consider its fundamental social and biological functions of a whole, or series of whole frameworks, and where we encounter significant differences—as we shall—we shall

attempt to explain them in terms of the whole to which they relate. In this way we may perhaps arrive at some common principles which may apply to man universally and in all societies.

The first point concerning which it is necessary to be clear is the position of man in the world as an animal organism Upon this elementary point there strangely seems to exist a considerable amount of confusion It is often stated that man is descended from a monkey or variously from the gorilla or the chimpanzee In such statements there is not an ounce of truth Man in common with these animals belongs to the same Order of Mammals, the Order of Primates, but his kinship with the monkeys is very remote, while his relationship with the African anthropoids, the chimpanzee and the gorilla, is collateral and not linear. That is to say, though the anthropoids and man were probably derived from the same stock, their evolutionary history has proceeded along disparate and divergent lines Thus, man is not descended from any existing anthropoid ape, but from the same stock as that from which the anthropoids also originated, hence, they may be regarded as at most collateral relatives or very distant cousins, and from the standpoint of the modern zoologist, members of the same extended family Fossil remains of an animal from which man and the anthropoids may have originated are known from the Miocene horizons of the Siwaliks of India, namely, the remains of *Sivapithecus sivalensis* *Sivapithecus* is known only from some fragments of upper and lower jaws and a good assortment of teeth, but these represent among the most valuable of the remains of any animal Comparison of these remains with the similar parts of anthropoids on the one hand, and human beings on the other, suggests that man has become a less specialized form, while the anthropoids have become comparatively excessively specialized. The moderately developed canine teeth of *Sivapithecus* have in man been replaced by a tooth the tip of which is almost level with the biting surfaces of the rest of the teeth, whereas, in the anthropoids, these teeth have been replaced by great tusk-like structures

There is a lesson which suggests itself here, and it is, I believe, a perfectly legitimate one to draw from the evidence The lesson is that specialization is achieved at the cost of general efficiency and leads to a constriction of the process of living or experiencing; whereas a general and well-integrated distribution of energies leads to an increase in general efficiency and an enlargement of the capacity to live and experience And this, essentially, is the difference between the apes and man The apes have pursued a developmental course which will ultimately lead to their extinction They are too narrow, too specialized. They can not compete with man The human species, on the other hand, has pursued a developmental course which has been characterized by its plasticity and adaptability, a plasticity and adaptability which has led mankind to the position in the world in which it now finds itself. Not "Nature's sole mistake," at least, not yet, but nature's most spoiled brat, perhaps, unquestionably nature's most promising child It need hardly be pointed out that spoiled brats and promising children are conditions frequently found together in the same individual. In terms of zoologic time, and in terms of experience, mankind is still in the childhood of its development. Of the future we can say very little. As a friend of mine, a garbage collector, once appropriately remarked, "If we take care of the present the future will take care of itself" The time for lamentation and jeremiads may safely be postponed to the end of the next half-million years,

when the original readers of this paper and its author may possibly figure in the cases of the Museum of the University of Pennsylvania as the fossil representatives of a race that thought it could beat the Philadelphia city tax on incomes—and maybe did!

This plasticity and adaptability which so conspicuously endows man, beyond all other animals, with the ability to control so much of the world in which he lives, is reflected both in the structure of his body and of his mind Both are the least specialized of any to be found in the Order of Mammals to which he belongs Now, this is an extremely important point to grasp, that is, that biologically man is both structurally and mentally the most plastic and adaptable animal in existence Structurally, this plasticity has enabled him to adapt himself to an untold variety of conditions Upon his inner genetic resources he has been able to draw for combinations of physical characters which have met the requirements of natural, sexual and social selection, which, as factors operating in geographically isolated localities have been instrumental in producing the varieties of man with which we are acquainted. Whether these varieties of man represent the effects of the action of mutant genes, of natural, sexual or social selection, or any combination of such factors, the outstanding fact remains that the group has varied in the way it has structurally without in any way losing its plasticity, indeed, there seems to have been a very definite gain in plasticity and adaptability

And here the important fact requires to be stated that all varieties of man belong to the same species, and without a doubt have the same common human ancestry This is the conclusion to which all the relevant evidence of comparative anatomy, hematology and genetics points. On genetic grounds alone it is virtually impossible to conceive of the varieties of man having originated separately as distinct lines from different anthropoid ancestors Genetically, the chances against such a process ever having occurred are in mathematical terms of such an order as to deny the suggestion even so much as a glimpse into the universe of possibility On anatomical grounds the evidence is quite clear The physical differences which exist between the varieties of mankind are, from the anatomical standpoint, so insignificant that when properly evaluated they can only be defined in terms of a particular expression of an assortment of genes which are common to all mankind And this one may say very much more definitely and with much greater justice than one may say it of the differences exhibited by any of our domesticated varieties of cats, dogs or horses There are numerous varieties of cats, dogs and horses, and these represent highly selected strains of animals which have been bred as more or less pure breeds and domesticated by man Man too is a domesticated, a self-domesticated, animal, but unlike our domestic animals the varieties of man are much mixed and are far from representing pure breeds. The range of variation in all human varieties for any character is very much more considerable than that which is exhibited by any group of animals belonging to a pure breed All the evidence indicates that the differences between the so-called "races" of man merely represent a random combination of variations derived from a common source which, by inbreeding in isolated groups, has become more or less stabilized and hereditary in a large number of the members of such groups. Furthermore, the evidence indicates that such selection of variations as has occurred in different groups has been restricted entirely to physical characters. There is no evidence among the varieties of mankind that any process of mental selection has ever been operative. The conception of selection for mental quali-

ties seems to be a peculiarly modern one, adapted to modern prejudices.

Man has bred dogs for certain temperamental qualities useful in the hunt—dogs like the Irish setter, for example. The Irish setter is always red-haired, but his red hair has no connection with his temperamental qualities Yet his hair color is often used as a tag or label for his temperamental qualities. The Irish setter has the same kind of temperament as the English setter, but the hair color of the English setter is white and black. The only difference between white, black, white *and* black and red setters lies in their coat color, and none at all in their mental or temperamental qualities No one ever asks whether there are temperamental differences between white, black or brown horses—such a question would seem rather silly; but when it comes to man the prejudice of any one who has ever made the statement that skin color is associated with mental capacity is accepted as gospel For such an assumption there is about as much justification as there would be for the assumption that there exist substantial mental differences between the differently colored varieties of setters We know this to be false for setters *only* because we have paid more attention to the character of the mental qualities of dogs than we have to those of human beings But those of us who have paid some attention to the character and forms of the mind of peoples belonging to different varieties of mankind and to different cultures have satisfied ourselves, by every scientific means at our disposal, that there exist no significant or demonstrable innately determined mental differences between the varieties of mankind. There is every reason to believe that such mental differences as we observe to exist between the different varieties of man are due entirely to factors of a cultural nature, and are in no significant way related to biological factors.

A question often asked is: Why do the cultures of different varieties of man differ so considerably from our own? The answer is really quite simple. Cultures differ from one another to the extent to which their experience has differed. No matter with what variety of mankind we may be concerned, or with what groups of a particular variety, culture is in its broadest and fundamental sense not merely an aspect but a function of experience. By experience I mean anything that an individual or group of individuals, has undergone or lived, perceived or sensed The reason why the cultures of different varieties of man are so different from our own is that these varieties have been exposed to experiences which differ as considerably from our own as do the cultures in question If you or I, with our present genetic background, had been born and brought up among a group of Australian aborigines we should have been, culturally, Australian aborigines, though physically we would remain members of our own variety. For experience is determined by the place and culture in which groups and individuals live, and it is for this reason that groups and individuals belonging to different cultures will differ mentally from one another Our physical structure would not have varied because it was genetically determined by our present parents, but our cultural equipment would have been that of an Australian aboriginal. Why? Because culture—and by culture I understand social behavior and all its products—because culture is something that one acquires by experience, unlike one's physical appearance, which one acquires through the action for the most part of inherited genes, and the culture of individuals, as of groups, will differ according to the kinds of experience which they have undergone The culture of different peoples, as of different individuals, is to a very large extent a reflection of their past history or experience. This is a

point which is worth more than laboring, for if the cultural status of any variety of man is merely determined by the kind of experience which it has undergone, then it is evident that by giving all people the opportunity to enjoy a common experience—supposing for the moment that this were desirable—all would become culturally and mentally equal; that is, equal in the sense of having benefited from exposure to the same kind of experience, and always, allowing, of course, for the fact that no two individuals can ever be alike in their reception and reaction to the same experience, and that there will always, very fortunately, continue to be great differences between individuals There can be very little doubt that genetic differences in temperament and intellectual capacity exist between the individuals comprising every variety of mankind, no two individuals in this respect ever being alike, but it takes the stimulus of a common experience to bring these out and to render them comparable. It is because of differences in cultural experience that individuals and groups differ from one another culturally, and it is for this reason that cultural achievement is an exceedingly poor measure of the value of an individual or of a group For all practical purposes, and until evidence to the contrary is forthcoming, we can safely take cultural achievement to be the expression merely of cultural experience. Obviously, all learned activities are culturally, and not biologically, determined, whether those activities be based upon instinctive urges or traditional practises The generalized urges which all human beings in common inherit continue to be present in all human beings in all cultures, but how these urges are permitted to operate, and how they are satisfied is something which is determined by tradition and varies not only in different cultures but in different groups within the same culture. For example, one of the fundamental urges which we all inherit is the urge to eat. Now, different human groups, to whom the same foodstuffs may or may not be available, not only eat different foods, but prepare them in unique ways, and consume them with or without implements in a variety of different styles, and usually for no better reason than that it is the customary practice to do so. The faculty of speech is biologically determined, but what we speak and how we speak is determined by what we hear in the culture in which we have been culturalized. Human beings everywhere, when they are tired, experience a desire to rest, to sit down, to lie down or to sleep, but the manner in which they do all these things is culturally determined by the custom of the group in which they live. Many other instances will doubtless occur to the reader's mind The point to grasp here is that even our fundamental biological urges are culturally controlled and regulated or culturalized, and their very form and expression, not to mention their satisfaction, moulded according to the dictates of tradition.

In view of the tremendous number of different cultural variables which enter into the structure and functioning of different groups and the individuals comprising them, it is surely the most gratuitous, as it is the most unscientific, of procedures to assert anything concerning assumed genetic conditions without first attempting to discover what part these cultural variables play in the production of what is predicated Obviously, no statement concerning the mentality of an individual or of a group is of any value without a specification of the environment in which it has developed The introduction of the *deus ex machina* of genetics to account for the cultural differences between people may be a convenient device for those who must do everything in their power, except study the actual facts, in order to find some sort of support for their prejudices, but it is a device which

will hardly satisfy the requirements of an efficient scientific method Such devices must be accepted in a charitable spirit as the misguided efforts of some of our misguided fellows to conceal the infirmities of their own minds by depreciating the minds of others. John Stuart Mill, almost a hundred years ago, in 1848, in his "Principles of Political Economy," put the stamp upon this type of conduct very forcibly, he wrote, "Of all the vulgar modes of escaping from the consideration of the effect of social and moral influences on the human mind, the most vulgar is that of attributing the diversities of conduct and character to inherent natural differences" While the number of people guilty of this vulgar error have greatly increased since Mill's day, the fraction of people who know it to be false has also greatly increased, and there is no need of despair for the future The facts which are now available concerning the peoples of the earth render it quite clear that they are all very definitely brothers under the skin

It would perhaps be too much to expect those who have been educated in the contrary belief to accept such a view, but the least we could do would be to provide the children in our schools with an honest account of the facts, instead of filling their guiltless heads with the kind of prejudices that we find distributed through so many of the books with which they are provided Surely, a sympathetic understanding of people who behave "differently," and who look "differently," can not help but broaden one's horizons, and lead to better human relationships all round? Socially, this is, of course, greatly to be desired, but it can hardly be said that much has yet been achieved in this direction There is here, obviously, a great deal of work to be done

But let us return to our main discussion, for though school children and others have frequently heard of physical relativity, few if any children, and hardly any others, ever encounter the concept of cultural relativity. From the standpoint of the well-being and happiness of mankind the latter is a vastly more important conception to grasp than the former. By cultural relativity I mean that all cultures must be judged in relation to their own history, and all individuals and groups in relation to their cultural history, and definitely not by the arbitrary standard of any single culture such, for example, as our own Judged in relation to its own history each culture is seen as the resultant of the reactions to the conditions which that history may or may not record If these conditions have been limited in nature, so will the culture reflecting their effects If the conditions have been many and complex in character, then so will the culture be. Culture is essentially a relation which is the product of the interaction of two correlates, the one a plastic, adaptable, sensitive, biological being, the other, simply —experience If we agree that mankind is everywhere plastic, adaptable and sensitive, then we can only account for the mental and cultural differences between the varieties of mankind on the basis of a difference in experience. And this, when everything is taken into consideration, seems to be the true explanation of the mental and cultural differences which exist between the varieties of man Let me give one or two examples of cultural relativity, as it were, in action

Five thousand years ago the ancestors of the present highly cultured peoples of Europe were savages roaming the wilds of Europe The ancestors of the modern Englishman were living in a Stone Age phase of culture, painting their bodies with woad and practicing all sorts of primitive rites, and culturally about equivalent to the Australian aboriginal—a state in which they continued for more than three thousand years until their discovery and conquest by the Romans

in the first century of our era. Five thousand years ago Europe was inhabited by hordes of savages, at a time when the kingdoms of Africa and the Babylonian empire were at their height Babylon has long since passed into history and the kingdoms of Africa have undergone comparatively little change; but five thousand years ago, and less, the natives of these great cultures could have looked upon the Europeans as savages equal to beasts and by nature completely incapable of civilization—and hence, better exterminated lest they pollute the blood of their superiors! Well, whatever sins the Europeans have since committed, they have at least shown that given a sufficient amount of time and experience they were capable of civilization to a degree not less than that to which Babylon and the kingdoms of Africa attained

Here we have an example of cultural relativity If we use time as our framework of reference and say "The Africans have had a much longer time than we have had to develop culturally as far as we have—why haven't they?" The answer is that time is not a proper measure to apply to the development of culture or cultural events, it is only a convenient framework from which to observe their development Cultural changes which, among some peoples, have taken centuries to produce, are among other peoples often produced within a few years The rate of cultural change is dependent upon a multiplicity of different things, but the indispensable and necessary condition for the production of cultural change is the irritability produced by the stimulus of new experiences Without the irritability of such new experience cultural change is exceedingly slow Hence, if new experience is the chief determinant of cultural change, then the dimension by which we may most efficiently judge cultures is that of the history of the experience which has fallen to the lot of the cultures observed In other words, to evaluate cultural events properly one must judge them by the measure of experience viewed through the framework of time We, of the Western world, have packed more experience into the past two thousand years than has probably fallen to the lot of the Australian aborigines and other peoples throughout their entire history Hence, any judgments of value we may attempt to make as between our own culture and that of other peoples will be quite invalid unless they are made in terms of experience Bearing this cardinal principle in mind, we shall be able to steer a clear course

If, then, the essential physical differences between the varieties of mankind are limited to superficial characters such as skin color, hair form and nose form, and the cultural and mental differences are due merely to differences in experience, then from the socio-biological standpoint all the varieties of mankind must be adjudged as fundamentally equal; that is to say, biologically as good and efficient as one another and culturally potentially equal All normal human beings are everywhere born as culturally indifferent animals, and they become culturally differentiated according to the social group into which they happen to be born Some of the culturally differentiating media are neither as complex nor as advanced as others, the individuals developed within them will be culturally the products of their cultural group As individuals they can no more be blamed or praised for belonging to their particular group than a fish can be either blamed or praised for belonging to his particular class in the vertebrate series Culture, the culture of any group, is more or less determined by accidental factors which the group, as a group, has usually done little to bring about The more advanced cultures have merely been luckier in the breadth of their experience, their contacts, than the less advanced cultures.

Culturally most people have solved the problems with which they have been confronted very satisfactorily—each in his own way—and the chief difference between a primitive and an advanced culture seems to lie in the number of problems which have been created and in the number and variety of the attempts made to solve them. Quantitatively, the number of problems with which the average individual in Western civilization has to grapple are far more numerous than those with which any member of a simpler society must deal—but it is doubtful whether he is for that reason to be regarded as a better human being than such a member of a less advanced society. The average product of the Machine Age is hardly an achievement of which to be proud

In judging cultures it is not so much the *quantity* of experience that matters as the *quality* A little experience of the right quality is vastly more important for human happiness than a large quantity of experience of the wrong quality. When the quantity begins to outstrip the quality there is a serious danger of quality going under altogether. We of the Machine Age are faced with such a danger. In spite of our enormous technological advances we are spiritually, and as humane beings, not the equals of the average Australian aboriginal or the average Eskimo—we are very definitely their inferiors We lisp noble ideals and noble sentiments—the Australians and the Eskimos practice them—they neither write books nor lecture about them Theirs are the only true democracies, where every individual finds his happiness in catering to the happiness of the group, and where any one who in any way threatens the welfare of the group is dealt with as an abnormality. In Western civilization untold millions of individuals are now engaged in catering to the welfare of a relatively few powerful individuals at the cost of their own welfare and happiness. There seems to be a strange confusion of values here, and it is in the nature of the confusion that the victims are unable to see the cause of it. When men take advantage of their natural democratic rights to advantage themselves at the expense of others—and therefore of the group—the development of the group ceases to be associated with the principle of the greatest good of the greatest number, and it is, I suggest, because we, as individuals, have lost sight of the very existence of this principle that Western civilization is to-day threatened with a bankruptcy of the spirit Let us learn, before it is too late, from those civilizations which were dominated by ruling castes who cared more about the preservation of their own privileges than for the good of the community, and which, becoming top-heavy, collapsed and perished. At the present time there remains one bank that still remains solvent in a gold-forsaken land where the prevailing religion is moneytheism, it is the Bank of Scientific Humanism. Its capital is unlimited, and it seeks clients who are willing to invest in human welfare and happiness. Let us draw upon this capital of ideas, not to hoard them, but to spend them wisely, and thus by our acts disseminate the currency of scientific humanism with which the happiness of mankind may be secured

SCIENCE AND CULTURE

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There is a growing interest in the relation of science to society as evidenced by the increasing number of public discussions, papers and books focussed on this question For the most part these discussions are concerned with applied science and technology or are carried on in terms of large abstractions, such as Science and Society, with a capital S. Little attention is being given to the influence of scientific advances upon the traditional Western European culture upon which our society and our personal lives are organized.

Discussion of this topic is difficult because at present we have so few clear ideas and little or no adequate terminology. Indeed, it may be said that we are only just beginning to gain an awareness of culture, a realization that we live in a culture and, as we shall point out later, that culture is in us In offering this discussion, therefore, it is hoped that the reader will be patient if it seems somewhat circuitous and at times puzzling If, however, we are seeking some understanding of the meaning and significance of science for culture, we must first seek a clearer picture of what culture means and does.

Man as an organism exists along with all other organisms in the geographical world of physical, chemical and biological events and processes that we call nature. Throughout the long period of animal evolution every other species has come to terms with nature by differentiation and specialization of structures and functions for its life zone or environment The persistence of some forms seemingly unchanged from the more remote horizons of geological time is convincing evidence of the effectiveness of these adaptations for survival. It is also eloquent testimony to the price that has been paid for survival on these terms because it has involved fixity and sacrifice of any further developmental changes.

Man, as we are beginning to realize, is unique because, unlike all other species, he has made his adaptations, not by organic specialization and bodily differentiation, but through ideas and the use of tools, whereby he has retained his organic plasticity, remained biologically young, unspecialized and capable of continued development [1] Until we pause and reflect on this human mode of adaptation, we may not realize the full significance of what man has attempted Instead of accepting one of the innumerable modes of biological existence, on the level of organic functioning and impulsive behavior, man has attempted to live in a world of his own creation. To do so it has been necessary not only to forego life on a biological level, but also to create the assumptions and the concepts upon which he could build this human world

At this late date in man's history it is impossible to speak with any surety about his early days, so that at best we can but hazard some surmise and suggest a few clues to an understanding of that past. Perhaps the most fruitful interpretation we can offer is to realize that from the beginning man has faced certain persistent tasks of life, namely.

1. To come to terms with nature in order to gain sustenance, to find security, and to achieve survival in a world both precarious and problematic

2. To organize a group life so that individuals can live together and participate in the division of labor, which group living both necessitates and makes possible.

3 To transform organic functioning and impulsive behavior into the patterned conduct of group life and of human living as distinct from biological functioning.

[1] *Cf* Julian Huxley, *Yale Review*, n.s., 28: 473–500, spring, 1939.

This contrast between man and other species provides a clue to the understanding of what we call culture It must be clear that if man was not to follow other species he must develop certain assumptions or beliefs about the world and himself that would not only justify but also compel him to act toward the world, toward other individuals and himself in ways that offered some solution to these persistent life tasks Here we face one of the major difficulties in discussing such a topic because in the endeavor to formulate this unique relation of man to the world and his fellows, the most extraordinary variety of ideas and concepts has been developed Whenever we attempt, therefore, to discuss this question we are almost inevitably betrayed by the very language we employ for that purpose Let us briefly pause, therefore, to see if we can make this situation clearer without importing into the discussion the usual mystical and subjective implications with which this topic has for so long been burdened

Each species has worked out a way of life by learning to deal with certain selected aspects of the environment. Thus we find in the same life zone insects, reptiles, birds and mammals finding sustenance and achieving survival, each, as it were, living in one of the many worlds which the environment provides for its selective awareness, specialized needs and differentiated capacities. These diverse but coexisting worlds are created out of the totality of nature by what each species responds to and what it ignores or disregards—by the perspective, if you please, which the environment presents to each organism

In these terms we may conceive of man as attempting to work out his way of life by and through the specific meanings, significances and relationships which he imputes to, or imposes upon, this same environment. He is still living in nature and he is still dealing with what is called the real world, but whatever he sees, thinks, feels and does is governed by these concepts and assumptions that he makes about that world and himself Culture, then, is the process by which man creates and maintains this peculiarly human world and mode of living, built in terms of the ideas and conceptions that he himself has created and imposed upon nature and himself All over the earth, therefore, we find different groups of people existing in this same geographical world of nature, but living in distinct cultural worlds of their own historical creation. Each of these different cultures may be looked upon as a different solution proposed by man to the persistent life tasks, in terms of its four basic organizing conceptions, namely.

1 The nature of the universe, how it arose, or was created, how it operates, who or what makes things happen, and why

2 Man's place in that universe, his origin, nature and destiny, his relation to the world, whether in nature or outside nature.

3 Man's relation to his group, who must be sacrificed for whom, the individual's rights, titles, duties and obligations.

4 Human nature and conduct, man's image of self and his motives, what he wants and what he should have, how he should be educated and socialized

From these four basic conceptions derive the systems of thought and logic, the standardized patterns of feelings and sensibilities and the criteria of credibility, with which the great historical cultures have been built All these are expressed in the religion, the philosophy, the law and the art of each cultural group

It begins to appear then that what we call culture is a way of ordering events, of organizing experience, of giving meaning and significance to the environing world and to man himself in terms of these basic organizing conceptions. Thus whatever exists and happens in the world will be seen and interpreted in the context of the ideas, beliefs and conceptions provided by each culture as the only socially sanctioned way of believing, thinking, feeling, acting and speaking

Just as we find in different species sensitivities or irritabilities to a given range

of stimuli or energy transformations, so that while existing in the environing world of nature they nevertheless live a restricted life in accordance with this selective awareness and the patterned responses dictated by their organic structure and functional capacities, so in the same way we may look upon man as creating his special cultural world out of the totality of nature and living strictly within the limits of its formulations and prescriptions Again it may be emphasized that while every other species has, through the mode of organic adaptation and specialization, reached the end of the road, so to speak, man has, through culture, developed what is often as coercive and limiting as organic adaptation, but still susceptible to modification and change, whenever he can and will change his basic ideas. Thus we may emphasize that culture is this historically developed way of ordering events, of organizing experience and of regulating conduct, which man himself has constructed and placed between himself and nature Whatever man does to gain sustenance, protection and security, and in his other dealings with his environment, will be governed by his basic conceptions, whatever tools and technology he develops will arise as implications and consequences of these conceptions and will be used only in accordance with these conceptions. Moreover, whatever regulations of his own functions and prohibitions and compulsions, that he lays upon himself and his conduct, will be dictated by his conception of the place of man in that universe, his ideas of the relation of the individual to the group and his conception of human nature and conduct. Whatever he does and whatever he refrains from doing will be expressive of an idea or belief about the world and himself Even when he repudiates and revolts against the dictates of his culture and the requirements of his society, he still acknowledges these ideas and these beliefs because only in the terms of his culture can he see, feel, think or act.

As we see in the religion and philosophy of each cultural group, these four basic organizing conceptions are interdependent, each giving and receiving sanction and support from the other three The specific formulations that derive from these basic conceptions are expressed in law, the arts and the innumerable other formulations through which a culture declares and maintains itself Moreover, these basic concepts, together with the selective awareness and sensibilities that they foster, and the patterns of thought, feeling and conduct that they sanction, permeate the whole complex of language and symbols, rituals and ceremonies, institutional practices, such as contract, barter, sale, marriage, political organization, etc, through and in which the social life is organized and carried on

Since man everywhere has found the same nature and faced the same persistent tasks of life, there is a more or less universal pattern of life to be found in all cultures, each of which, however, has utilized different concepts, different meanings and purposes within this general framework In each culture, moreover, there is a theory of origins which tells how these basic organizing conceptions of life, this extraordinary complex of beliefs, patterns of conduct and feeling, have come from some superhuman, supernatural source and may therefore neither be questioned nor tampered with Only recently, therefore, and then only in our own culture, have we begun to realize that culture is a historically developed effort of each group to meet the persistent tasks of life—the human creation of man himself in an attempt to order events, organize group life and regulate his conduct as an alternative to a purely biological mode of existence. It is only recently, also, that we have clearly understood that this immense cultural organization depends for its continuation and maintenance upon the acculturation of each generation of children, who must be taught these basic ideas and conceptions, this selective awareness, these sen-

sibilities, these socially approved ways of thinking, believing, acting and feeling for meeting the persistent life tasks that each generation must face. Only in so far as children learn to see the world in these terms, to accept these cultural formulations, to observe these group-sanctioned patterns of conduct and speech, only thus does a culture persist. Moreover, only in so far as each child is socialized and taught the socially approved rituals, symbols, ceremonies and patterns of conduct, will the social life continue. It is evident that what the family teaches the child will be one version of the required cultural lessons and socialization, biased by the family's predilections and warped by the parental feelings about those lessons and toward the child Moreover, the child will learn from those lessons only what they mean to him and always in accordance with the feelings aroused by the parents and their requirements. The great diversity of individual conduct, beliefs and feelings therefore become explicable in the light of this process that creates the idiomatic individual and his unique personality We must continually remind ourselves that there is nothing in the natural, biological situation which requires or necessitates any particular culture or social organization. Nature, as it were, has been patient of the amazing variety of cultural formulations and social organizations which all over the world man has laid upon nature and himself

The ancient belief that culture and society are super-organic, superhuman organizations, operating through large-scale, cosmic forces, like gravitation, wholly above and beyond human direction and control, becomes increasingly incredible, as we are beginning to recognize culture and society as the answers proposed by man himself to the same persistent life problems If and when we do recognize the human origin of culture and of society and understand them as attempts to order events, to organize experience and to regulate conduct, then we can understand more clearly what the activity we call science means to our culture.

As suggested earlier, each culture is built upon the four basic organizing conceptions through which each group has attempted to give meaning and significance and order to its life, namely:

1. The nature of the universe; how it arose, or was created, how it operates; who or what makes things happen, and why.
2 Man's place in that universe; his origin, nature, and destiny, his relation to the world; whether in nature or outside nature
3 Man's relation to his group, who must be sacrificed for whom, the individual's rights, titles, duties and obligations
4 Human nature and conduct, man's image of self and his motives, what he wants and what he should have, how he should be educated and socialized.

In these conceptual formulations therefore are expressed whatever knowledge and understanding man has about the world and himself, organized and interpreted by reflective thinking, creative imagination and the aspirations and sensibilities cherished by the group We may, therefore, say advisedly that each culture is an expression of the knowledge and beliefs that were available during the period of its creation and formulation. In every other culture but ours, once these formulations had been achieved and translated into a living and continuing society, they have become final and unquestionable, and the major efforts of the leaders of each group are directed to preserving and strengthening the continuity of their traditions and the full force of their sanctions. This almost universal preoccupation with the maintenance of the cultural traditions against any doubt, skepticism or change becomes explicable when we realize that the whole structure of a culture and of the social life of the group rests upon the affirmation and acceptance of certain ideas, beliefs and concepts. If man is to have any order in his group life and any meaning and design in his personal living he must make such affirmations and

perpetuate them through inculcation in his children. Thus in every group, so-called primitive or so-called civilized, there is this unformulated but intense conviction that the children must be instructed in the group-sanctioned ideas, beliefs and patterns of conduct and forced, often by terror and brutality, to accept and conform

Western European culture is unique in that it has developed, and to-day is now institutionalizing, what might be called the "technique of habit breaking," that is, a systematic, critical examination of every idea, conception and belief about the universe and its operation, about man's origin and place in that universe, and every time-honored, traditional pattern of social life and individual conduct

Seen in this context, therefore, what we call science may be interpreted as the most recent of man's cultural inventions Not content with having built up a cultural world and thereby giving human life the orientation and direction that has made man a unique species, we now see that same human impulse directing man toward a continuous, critical examination of his culture in the attempt to escape that same crystallization and fixation in his culture as in his biological evolution If we can see science in these terms, we will see it not as some special, outside force or agency, but as a part of Western European culture, a further development and refinement of the creative activities which led man to create his culture in the attempt to order events and organize experience.

If, however, we are to understand the present situation in Western European culture and the occasion for discussions such as these, we must look back and see how the four basic organizing conceptions of our culture were developed through a long, historical process of many converging streams, coming from the major cultural groups around the Mediterranean Basin, chiefly Egyptian, Chaldean, Assyrian, Hebraic, Greek, Roman and Arabic, and later the northern European groups. Slowly there was evolved out of these many cultural streams and influences a more or less unified body of ideas and beliefs and conceptual formulations expressive of the best knowledge and understanding then available. Within the past four or five hundred years this traditional Western European culture has been under critical scrutiny, beginning with Galilei and with Copernicus, Kepler and Newton, the basic organizing conceptions of Western European culture have been rendered increasingly untenable and incredible First astronomy made obsolete the historical conception of a geocentric universe of limited spatial dimensions and temporal duration The classic conception of the order of events and the relationships among natural processes became increasingly unacceptable as physics, and later chemistry, brought new understandings and concepts More recently we have seen how geology and paleontology have necessitated a further revision of our basic conceptions of the world and of man, have enormously increased our time perspectives[2] and brought a new conception of man's place in the universe and his relation to nature Within our own generation biology and anthropology and historical research have led to further revisions of our traditional beliefs about the nature of man, his relationships to group life and his social, economic and political theories and organizations. To-day, biology, psychology and psychiatry are bringing a new conception and understanding of human nature and conduct, the implications of which are so far-reaching that we can scarcely grasp their significance.

The critical situation in which we find ourselves to-day may therefore be described in these terms Western European culture, like all other cultures, is a historical creation in terms of certain basic organizing conceptions which express the best knowledge, understanding,

[2] *Cf* the writer's paper, "Time Perspectives," *Journal of Social Philosophy*, 4: 4, 293–312, July, 1939

sensibilities and aspirations at the time of its formative period Within the framework of these concepts and the culture to which they gave rise, Western European peoples have faced the persistent tasks of life, of ordering events, organizing their experience and regulating their conduct, achieving what is writ large in their historically developed societies. This same culture has given rise to the dominant character structure and has fostered the personalities, the bearers of which are the active agents in the social, economic, political and international affairs, and so are responsible for the persistent disorder, conflicts and destruction recorded by that history [3]

For several centuries these basic concepts and beliefs of Western European culture have been losing their validity and their credibility Just as we have seen how other cultures have disintegrated, with increasing social disorder and individual demoralization, under the impact of European ideas, techniques, and teachings, so we are beginning to realize that our own culture has been cumulatively undermined by what we call scientific investigation, so that we no longer can accept or believe the older ideas and concepts. This process of disintegration has not been uniform, so that we find not only different groups of people, but also single individuals reflecting these changes in different areas and to different degrees Thus some sections of the population have been relatively untouched by any new ideas and so they continue to live in terms of the traditional formulations untroubled by any doubts or anxieties over the crucial aspects of life Other sections of the population only partially accepting new ideas are attempting to live in terms of the old and the new, facing increasing difficulty and strain while trying to reconcile the growing incongruities and discrepancies in their lives.

[3] *Cf.* the writer's paper, "Cultural Coercion and Individual Distortion," *Psychiatry*, 2 1, 11–27, February, 1939.

If time permitted, it would be interesting to examine some of these ever-widening chasms in our individual and group lives, as, for example, our demand for modern medicine while we continue to reject man's mammalian ancestry which gives modern medicine its validity Likewise we might reflect upon the difficulty of administering the law upon assumptions about the cosmos and human nature that are becoming progressively obsolete and absurd But such an inquiry would lead into every aspect and phase of society and individual living, where we see increasing disorder, conflicts and confusion as we face the persistent tasks of life for which our culture no longer provides guiding concepts and patterns and sanctions From this cultural view-point, the bewildering array of social problems, of internal and of international chaos and conflict, as well as the mounting anxiety and insecurity in our personal lives, appear as symptoms of the breakdown of the older Western European culture

In the midst of these alarms and conflicts, the question of what men of scientific persuasion can do becomes one of the crucial issues of our time The task of rebuilding our culture, of constructing a new framework of concepts and beliefs to give order, meaning and significance to life becomes ever more insistent But, it must be clearly recognized, this is essentially an artistic task, of creating a consistent picture of the universe and of man that will not only satisfy our new criteria of credibility, but also express the new aspirations and sensibilities through which we seek to attain the enduring human values More concretely, we must courageously and imaginatively create the four basic organizing conceptions essential to culture—the nature of the universe, man's place therein, his relations to his fellows and his society, and human nature and conduct—utilizing our recent scientific knowledge and understanding for that purpose, just as our predecessors utilized the best contem-

porary knowledge and understandings available to them for constructing the culture they bequeathed to us.[4]

The more clearly we realize the stupendous achievements of the past in building up Western European culture and sincerely recognize our indebtedness to those great leaders who created this amazing structure of ideas and beliefs and aspirations, the greater are our obligation and responsibility to do for our time what they did for their age This is the very ideal of scientific endeavor, to carry forward the task of ordering events, of reorganizing our ideas and procedures, in our never-ending pursuit of understanding the world and all it contains, including man and his culture

Until we formulate the *meaning*[5] of modern science for these essential concepts and beliefs, we must continue to live anxiously and contingently, unable to achieve any order in our society or our personal lives, because we lack this unified set of concepts through which alone we can order events, organize experience, regulate conduct and find dimensions for our values and aspirations To find the courage and faith for such a gigantic task, amidst the chaos that now threatens, we shall have to remind ourselves and our children that, however dark and threatening the future, man can now imaginatively project ahead a culture dedicated to the conservation of those human values that for long he has vainly sought[6]

In the years to come it is probable that this discovery of the human origin and development of culture will be recognized as the greatest of all discoveries, since heretofore man has been helpless before these cultural and social formulations which generation after generation have perpetuated the same frustration and defeat of human values and aspirations So long as he believed this was necessary and inevitable, he could but accept this lot with resignation Now man is beginning to realize that his culture and social organization are not unchanging cosmic processes, but are human creations which may be altered For those who cherish the democratic faith this discovery means that they can, and must undertake a continuing assay of our culture and our society in terms of its consequences for human life and human values. This is the historic origin and purpose of human culture, to create a human way of life To our age falls the responsibility of utilizing the amazing new resources of science to meet these cultural tasks, to continue the great human tradition of man taking charge of his own destiny.

[4] *Cf* John Dewey, "Theory of Valuation," International Encyclopedia of Unified Science Volume II, No 4, 1939, University of Chicago Press, page 66 "The chief *practical* problem with which the present *Encyclopedia* is concerned, the unification of science, may justly be said to center here, for at the present time the widest gap in knowledge is that which exists between humanistic and non humanistic subjects The breach will disappear, the gap be filled, and science be manifest as an operating unity in fact and not merely in idea when the conclusions of impersonal non-humanistic science are employed in guiding the course of distinctively human behavior, that, namely, which is influenced by emotion and desire in the framing of means and ends, for desire, having ends-in-view, and hence involving valuations, is the characteristic that marks off human from non-human behavior On the other side, the science that is put to distinctively human use is that in which warranted ideas about the non-human world are integrated with emotion as human traits In this integration not only is science itself a value (since it is the expression and the fulfillment of a special human desire and interest) but it is the supreme means of the valid determination of all valuations in all aspects of human and social life"

[5] *Cf* the writer's paper, "General Education," *Social Frontier*, March–April, 1937. It must be emphasized that we need more than abstract scientific laws, generalizations, quantitative findings and formulas, we are waiting for a statement of the *meaning* of scientific knowledge in terms of its emotional significance for living, so that modern astronomy, geology and biology will provide the equivalent of "Now I lay me down to sleep," in which the traditional cosmology, biology and psychology were expressed

[6] *Cf*. Ortega y Gasset, "The Modern Theme," New York, Norton, 1933.

A SERPENT-SEEKING SAFARI IN EQUATORIA

I. UGANDA

By ARTHUR LOVERIDGE

CURATOR OF HERPETOLOGY, MUSEUM OF COMPARATIVE ZOOLOGY, HARVARD COLLEGE

THREE liners lay alongside Kilindini wharf disgorging their human freight into the vast customs' shed, where mountains of baggage already awaited the attention of two harassed Kenya officials. A small group of importuning arrivals tagged after the tired two each time they moved. A babel of voices, chiefly Swahili, rose to such a crescendo at times that it was necessary to shout even when addressing persons close by Despite the wharves, cranes, sheds and obvious attempts at organization, Kilindini remains, in essentials, much the same as twenty-five years ago Naturally we were glad to escape from the orgy and retreat to the steamship *Llandovery Castle* for lunch before the second ordeal of entraining for the long journey up-country.

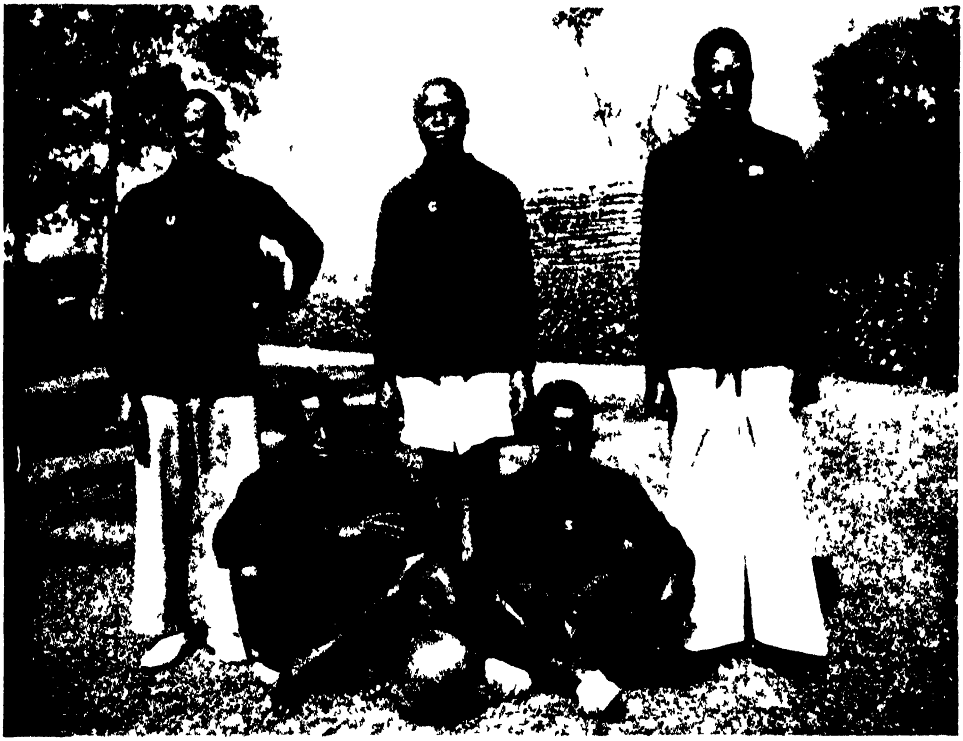
The expedition may be said to have commenced when we were roused at 11·30 P M in a London hotel by a telegram which read something like this: "As possibility *Llandovery Castle* may be rerouted by West Coast, sailing in twelve hours, do you wish to cancel reservations?" for this was September and at the peak of the Munich crisis. Since we certainly did not propose to alter our arrangements, the next afternoon found us in the ship's lounge listening to a dissertation on what to do in the event of an attack by machine-gunning planes, by bombers, by submarines or a combination of all three! In the raw greyness of that late September evening the sight of destroyers patrolling the turgid waters off Dover gave confidence.

Well, here we were at Mombasa at last with glorious months of open-air life ahead of us, during which weeks at a time, would slip by without our hearing any news of troubled Europe The purpose of my visit* was to investigate the fauna of various patches of forest. Some of these had already suffered pitifully at the hands of man so that the animal life which had flourished there in bygone days was depleted or had disappeared. Other forests proved almost virgin, and served as a check on conclusions drawn from those where destruction by fire and axe had already affected the fauna

Our first destination was the Mabira Forest, which covers some 120 square miles. A rubber concession in this forest was under the management of the well-known Uganda planter, Mr. J L. Jarvis, who not only placed an empty house at our disposal, but had the encroaching tangle of vegetation surrounding it cleared away, and generously drove us to it from Jinja. As we neared our destination he ran over a large example of the commonest of African blind snakes Jarvis pulled up while I ran back to pick up the poor creature. Strangely enough, not another of the species was encountered until my cook found one at my last camp on Magrotto Mountain, near Tanga, nearly 900 miles away.

We had scarcely settled in when a black snake with narrow white crossbands was found by the table boy on his way from kitchen to table This venomous garter snake (*Elapsoidea*), a relative of the cobras, was extremely common on Magrotto, but not met with elsewhere during eight months of persistent collecting!

* As a Fellow of the John Simon Guggenheim Foundation.



THE COOK AND SKINNERS, FORMING THE EXPEDITION'S NATIVE PERSONNEL

FIVE JERSEYS WERE BOUGHT ON THE OUTWARD VOYAGE AND ALL LETTERS EXCEPT ONE PICKED OUT OF EACH U C M S CO SIGNIFIED UNION CASTLE MAIL STEAMSHIP CO THE COOK, BLAZIO, IS STANDING AT THE RIGHT, WHILE THE SKINNERS, KIZAMBA (LEFT) AND ALI (RIGHT), ARE SEATED

Collecting is truly full of surprises Coming to a clearing in the forest where a native had a small plantation of coffee trees I hailed the owner with the news that any snakes which he brought to my camp could be transmuted into cash at the rate of 30¢ (8 cents U S) each "I saw one only a few minutes ago which you can have," said he, and walking to a coffee tree in the last row adjoining the forest, pointed out a young boomslang Though the large-eyed, chunky headed youngster belonged to one of the commonest African species, we never saw nor collected another during the course of the *safari*, despite the fact that about 650 snakes of 71 species were preserved! Here in the Mabira Forest we also took two snakes, one of which was entirely new to Uganda, while the other furnished a furthest east record of the black-and-red snake (*Bothrophthalmus*), common in Liberia and the Cameroons

Best of all our animal acquisitions at Mabira was a live tree pangolin which reaches the limit of its eastward range in Mabira This queer, long snouted, viscous-tongued termite-eater is covered with large scale-like plates When disturbed it curls up, presenting its armor-plating to the world, and is consequently often mistaken for an armadillo by Europeans on the rare occasions on which they have the good fortune to see one

One day a babel of hoarse cries and the tinkling of bells, as two curs ran hither and thither through the scrub fringing the forest, advertised the fact that a buck hunt was in progress All afternoon the uproar waxed and waned as the persistent huntsmen searched the

scrub. After sunset we saw the party returning with a little buck of a race of the blue-grey forest duiker. I bought it for a shilling, and after I had taken its measurements one of my skinners got to work on it. But Kizamba, the young huntsman who had brought the animal onto the veranda, growing impatient at Ali's slow and careful skinning, began to help. I noticed his skilful, quick manipulations, so when he said, "I like this work, I'd like to work for you," I agreed immediately.

THE NATIVE-DRIVEN TRUCK STARTING FOR BUDONGO WITH FIVE MEN AND A TON OF EQUIPMENT, SELECTED A SOFT SPOT IN MABIRA'S RUBBER PLANTATION

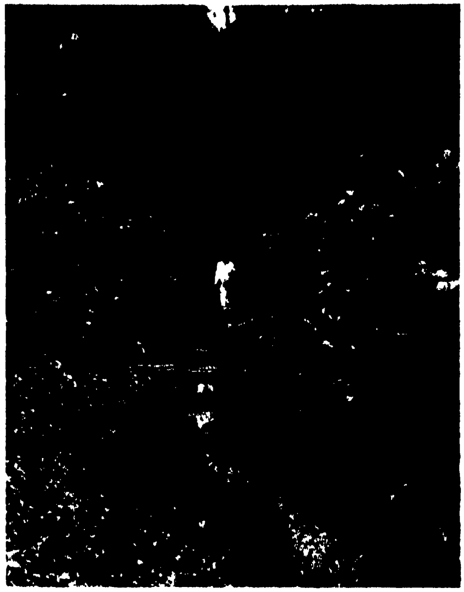
Thus it came about that Kizamba remained with me for the whole trip and proved to be the most fearless and nimble catcher of rats and lizards. To see him poised, half-crouching, bright eyes intently fixed on some hole that was being excavated by a companion, was sheer delight. When the occupant of the hole dashed out it was rarely that it escaped, for Kizamba would pounce upon it with a flat palm and seize it by the neck. "Kizamba *sawasawa paka*" (Kizamba is just like a cat), Yolan had remarked on one of these occasions, much to the amusement of all concerned. Every now and then the razor-sharp teeth of some hapless rodent would be buried in a finger. Kizamba might wince as the iodine was being applied, but was never deterred by such incidents. He was a born hunter and as we crept through forest undergrowth in pursuit of wary crested guinea-fowls, he would pause on one foot, the other upraised, looking for all the world like a human pointer or setter. As a skinner he was less skilful than Ali, but when he could be spared to accompany me I knew that the trip would be more fruitful, for many a time his sharp eyes detected some slight movement that I had failed to notice.

We left Mabira by lorry for the Budongo Forest, not far from Butiaba on

the northeastern shores of Lake Albert. Here we pitched our tents in a forest-nursery beside the Buchanan Sawmills, where 300 natives were employed. This site offered the advantage of a road cut into the heart of the forest, but as we were to discover later, the terrifying noise, both by day and night, made by caterpillar tractors drawing logging trains, had scared the creatures of the wilds further afield.

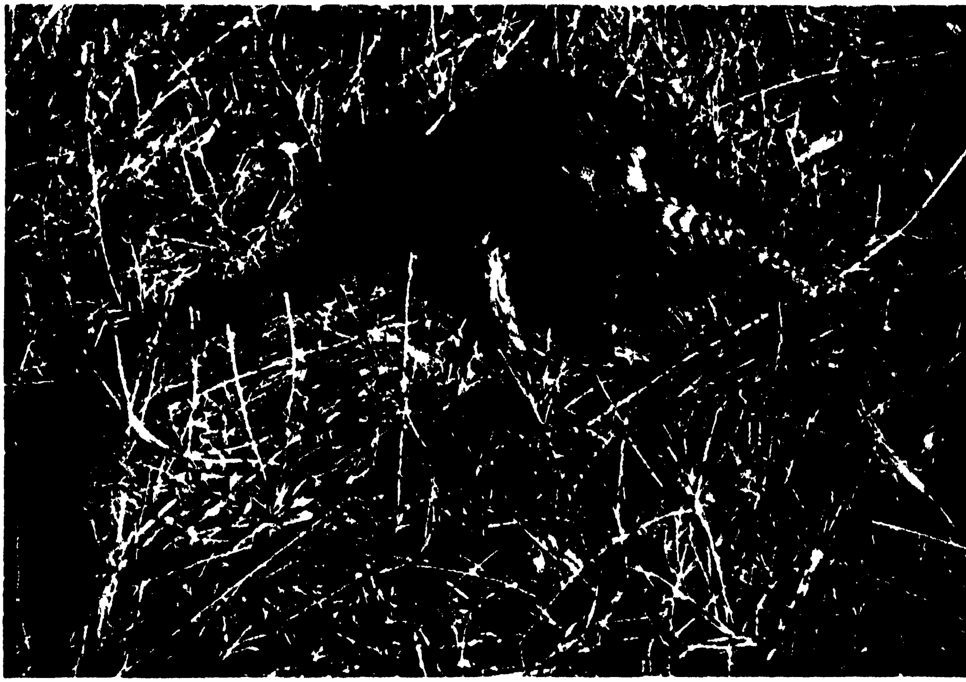
Snakes of course were unaffected and at first the prospects were promising, for on the very afternoon of our arrival an interesting tree-snake fell on a party of natives who were engaged in shifting balks of timber right in front of our tent. A big black-and-white cobra was brought in by a tree-felling gang at the end of the day. However, not another serpent did these men bring in during the remaining fortnight, possibly, in comparison with their good wages, they thought the 30 cents (East African) per snake too paltry.

Next day our "boy" Zachio, engaged in setting the table, was bringing something from the kitchen (a fire in the open) when he jumped, yelled "snakes" and made a dash for the tent. Snatching up my snake-stick, I ran back along the narrow path, freshly made through a luxuriant growth of vegetation. Thirty feet from our tent I caught sight of two velvety-green night adders, which had been scared into the grass by Zachio's appearance and were now returning. The anterior third of each was raised high, and so flattened that for a second I thought they were young cobras. They were almost intertwined, their lower portions so close together that I pinned both down with my T-ended stick. At this one reptile began to savagely bite the other's neck, enabling me to seize both together with the forceps. In this way I carried them back to the lethal tin in which some hundreds of snakes were destined to pass



NATIVE PATH IN MABIRA FOREST
OWING TO DENSITY OF UNDERGROWTH IN UGANDA FORESTS, COLLECTING WAS LARGELY RESTRICTED TO THE VICINITY OF SUCH PATHS

SNAKE'S EGGS FROM LAKE MUTANDA
HUNDREDS OF EGGS OF MANY SPECIES OF SNAKES WERE BROUGHT TO CAMP. THOSE OF THE RARER KINDS WERE CARRIED TO THE CONGO, WHERE THEY HATCHED



A LONG-SNOUTED, VISCOUS-TONGUED TERMITE-EATER
THIS STRONGLY CLAWED CREATURE CURLS WITHIN ITS SCALE-LIKE DEFENSIVE ARMOR AFTER THE MANNER OF AN ARMADILLO

their last moments "A courtship performance," thought I, but subsequently, on examining the two beautiful creatures, found both were males, so it was nothing but a fight after all—the flattened necks an attempt at intimidation!

Three days later an Indian arrived on a cycle to say that there was a big snake, thicker than his arm, near his house. I ran most of the quarter-mile there and found three Indians, armed with poles, surrounding a patch of grass in the middle of the path where two ways met. The snake, they said, was in this. In vain I scrutinized the spot, expecting a python, until one of my boys pointed out the great flat head of a Gaboon viper within two feet of me. The five-inch wide head looked like one of the many leaves scattered about, the rest of the reptile was entirely concealed by the grass. So torpid was its behavior that it never moved when I planted my stick upon its nape, nor when I picked it up in my hand, neither did it attempt to strike when I transferred it to a bag in which to transport it back to camp. The bulky creature, though measuring only fifty-one inches, weighed eight pounds. Another of these vipers, taken on Magrotto Mountain eight months later, was two inches longer yet weighed eleven pounds, for she held forty-three eggs.

In December we left Budongo Forest and drove southwards through Fort Portal—where a native brought us one of those ridiculous, elongated, snake-like lizards (*Chamaesaura*) whose hind limbs are reduced to little flaps, with or without minute digits—thence to Kibale Forest. A road had been cut recently through the southern portion of this great forest, but we had to make camp two miles in where an unbridged stream barred further progress to cars. It was successfully bridged by a labor gang

SEEKING CAMP SITE, IN BUDONGO FOREST OF NORTHWESTERN UGANDA
FOR AN HOUR WE TOURED THE FRINGE OF THIS MIGHTY FOREST SEARCHING FOR A CAMPING SITE

under native foremen just before we left, meanwhile we crossed it daily on a tree-trunk and gained access to several more miles through virgin forest

Kibale will be remembered principally by the wonderful profusion of its gorgeous butterflies and the abundance and tameness of its monkey-folk Several of the trees beside our tents bore fruit beloved by the simians and proved such an attraction that we counted no less than six species within a hundred yards during our ten-day stay The only timid ones were the beautiful black and white colobus, huge bands of the rufous-capped colobus roamed these woods and greeted a shot with a terrific outburst of menacing cries and grunts Then there were the mangabeys whose black faces and blackish-brown hair make them the Negroes of monkeyland Nor shall I forget a bold little Schmidt's monkey which descended a slender branch already borne down by a heavy green fruit the size and shape of a cannonball The monkey gnawed at the coveted fruit on which it sat, while momentarily one expected the slender stem from which it hung to give way under the additional strain In addition to the six species seen, we often heard the raucous cries of chimpanzees reverberating through the forest

As a corollary to the presence of so many monkeys there were thousands of flies, worse still, a disgusting parasite which assailed the nostrils of our native staff Fortunately Blazio, our cook, was acquainted with the correct technique for their removal A needle and thread were passed through a fine, stiff, yet hollow, grass stem, then back again so as to leave a loop at one end The noose and grass were then passed up the nose and after a little angling the maggot would be snared and jerked from its hold, sometimes a good deal of bleeding accompanied the operation

IN THE SECLUSION OF OUR CAMP IN THE BUDONGO FOREST
FINALLY WE FOUND SPACE FOR THREE TENTS AMONG YOUNG MAHOGANY TREES AT THE FOREST EDGE THE DRYING CAGE FOR BIRD SKINS IS IN FOREGROUND

LOGGING MAHOGANY FOR THE BUCHANAN SAW MILLS
THE CLEARING FOR THIS TRAMWAY, RUNNING FOR MILES INTO THE HEART OF THE FOREST, PROVIDED A GOOD MEANS OF REACHING THE FOREST DENIZENS

One day as I was hunting in this forest I came upon the first *living* black-striped tree-snake (*Hapsidophrys*) that I had yet met The beautiful and harmless velvety-green reptile was on a level with my face as I pushed through the bushes, for it was gracefully entwined about a spray of evergreen It made no attempt to bite when lifted down, nor subsequently under considerable provocation during the tedious process of posing it for its portrait, the sense of which it could not comprehend!

From Kibale we departed for Bundibugyo at the northwestern foot of the Ruwenzori Range, by a mountainous escarpment road that had only just been completed The scenery, chiefly by reason of its stupendous scale, was magnificent Frequently we crawled round some corner, the rock-hewn cliff towering above us on one side, while on the other it fell abruptly away to a grass-grown gorge a thousand feet below

A few years before, Captain Pitman, who has done so much to advance our knowledge of Uganda snakes, added two species, obtained in Mabira, to the Uganda list Another example of one of these reptiles, an arboreal spitting cobra (*Naja goldii*), was brought in by two Bwamba natives at Bundibugyo, since it measured 7 feet 1 inch in length it is probably the longest of its kind taken anywhere, as well as the second known Uganda record Here also we got the second example of the other tree snake (*Boiga pulverulenta*)

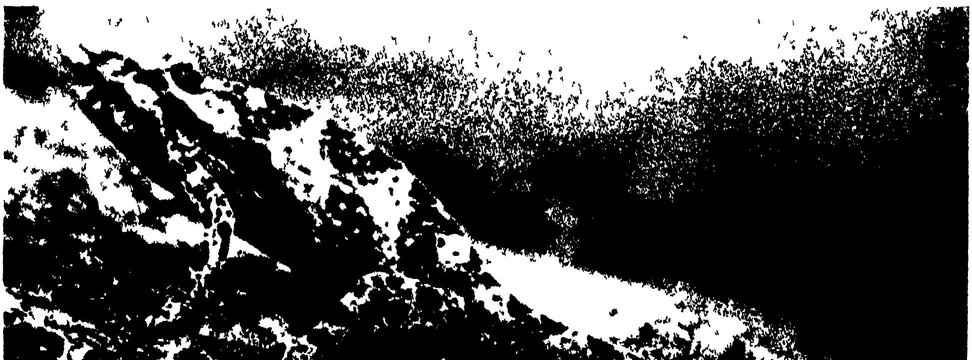
The lorry which was to come from Fort Portal to take us three quarters of the way round Ruwenzori was several hours late As we climbed back up the

HUNTING A COBRA AT BUDONGO WITH NATIVE ASSISTANCE

THE REPTILE HAD BEEN SEEN CROSSING A PATH WITH A LARGE RAT IN ITS MOUTH IT SOUGHT REFUGE BENEATH THE LOG

AN ARBOREAL SNAKE FROM KIBALE FOREST AND A FOUR-TOED SKINK

THE BEAUTIFUL GREEN SNAKE ABOVE WITH TEN BLACK LINES ALONG ITS BACK, FORMS AN INTERESTING PARALLEL TO THE ROUGH GREEN SNAKE OF OUR SOUTHERN STATES. THE BURROWING LIZARD BELOW, KNOWN ONLY FROM THE RUWENZORI RANGE, WAS DISCOVERED IN 1905. NO SECOND EXAMPLE OF THE TYPICAL FORM WAS FOUND UNTIL THE PRESENT TIME WHEN MANY, TOGETHER WITH THEIR EGGS, WERE COLLECTED.

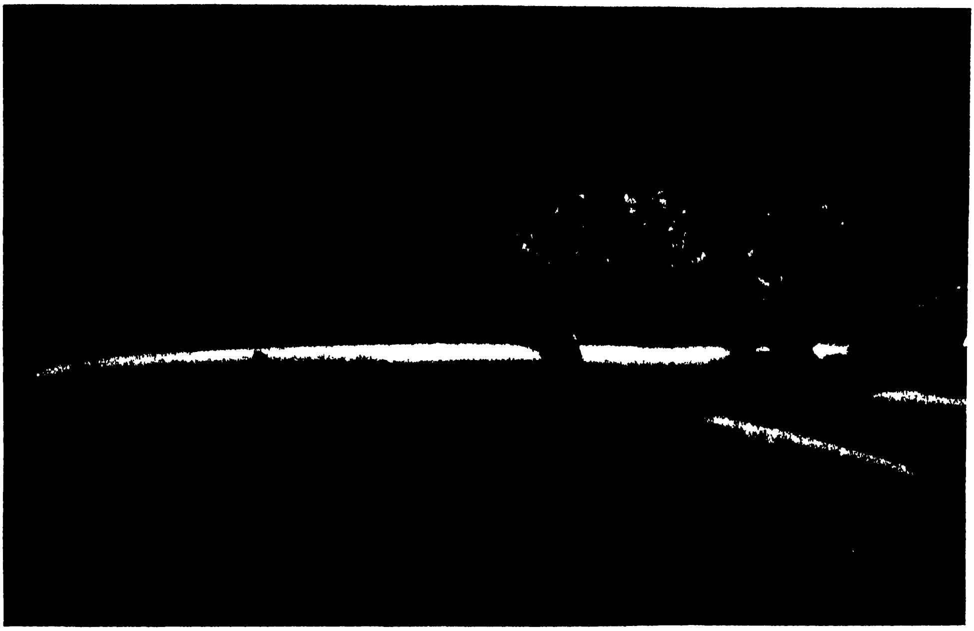


JOHNSTON'S CHAMELEON FROM MUBUKU VALLEY

THE MALE CHAMELEONS ARE HORNED. WE HAVE SEEN THEM USE THEIR WEAPONS TO PROD EACH OTHER WHEN A SHRUB WAS TOO SMALL TO SUPPORT TWO OF THESE BEAUTIFUL CREATURES.

terrific escarpment road we developed engine trouble, which resulted in so many delays that the sun was setting by the time we reached the rest camp at Bugoye, where a cold wind was whistling down the valleys from the glaciers above, the latter hidden by intervening ridges. In fact, one might camp at Bugoye in complete ignorance of the proximity of a 16,800 foot mountain.

Three men had been sent ahead to cut a path through the tangle of vegetation straight up the hogback to the fig tree instead of following the horse-shoe-shaped ridge around the head of the valley. This is the track taken by many natives; when asked, however, why they had guided us the longer way, they replied that it was the custom, for all expeditions had taken that route! From fig-tree ridge we had magnificent views of the snowy peaks, indescribably beautiful when tinged by the rosy glow of sunset.



THE FEMALE OF A RARE SPECIES OF RUWENZORI CHAMELEON

THE FIRST PHOTOGRAPH OF THE HORNLESS FEMALE OF A SPECIES HERETOFORE UNREPRESENTED IN ANY AMERICAN MUSEUM. THE CREATURE IS RARE BECAUSE IT DWELLS IN THE FOREST CANOPY

We found their work pretty sketchy in places, but the task was a tremendous one. Up and up we toiled in the midday heat, sun smiting upon bent backs. From Bugoye to the campe-site beneath the great fig tree on Mihunga ridge is said to be a four-hour climb. I managed to do it without a load, but the porters took from six to eight hours. Later I discovered a much easier route and one which takes little cutting, *viz.*, through a swamp at the very foot of Mihunga, thence

Next day we dropped down into the Mubuku Valley, slopped our way through a swamp, then recommenced the tedious ascent of the valley. I pushed on to select a camping site, on through the forest out into the grassland beyond, always urged onward and upward by our guide, who recommended some site "just a little farther on." Eventually I protested that I was sure that the forest through which we had passed would prove more suitable for my investigations

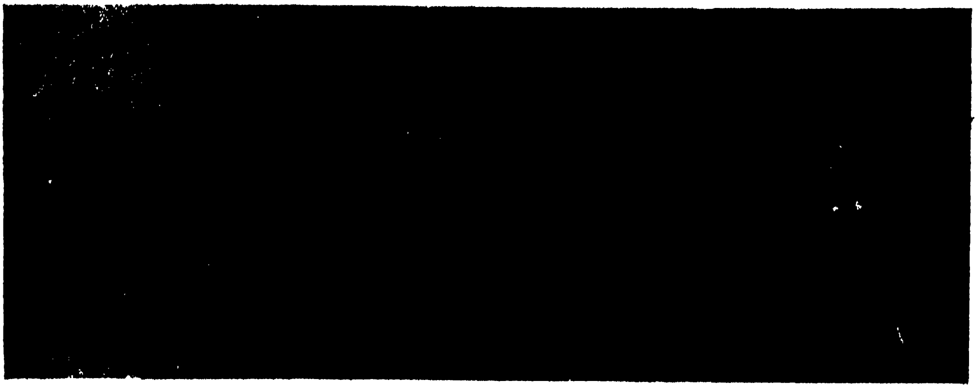
A MARKED GABOON VIPER AND A SLEEK BLIND SNAKE

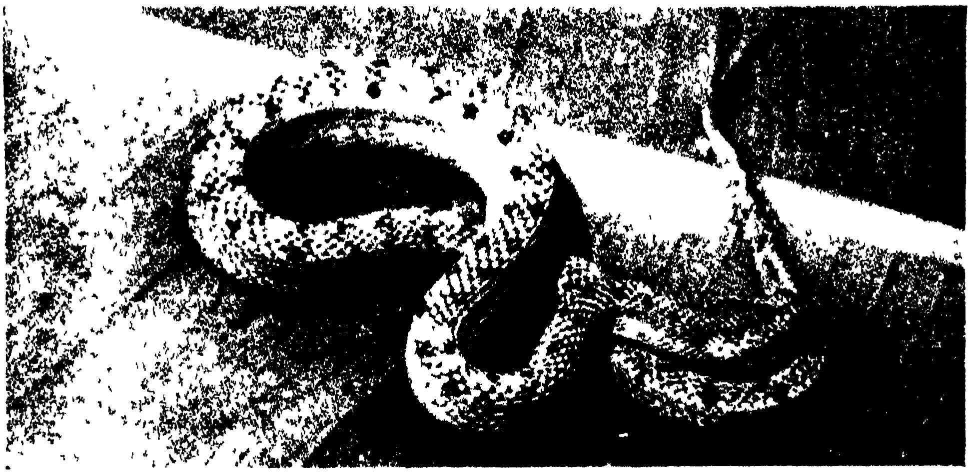
THE SLUGGISH FIFTY ONE INCH SNAKE ABOVE, FROM THE BUDONGO, WAS FOUND BY AN INDIAN CONCEALED IN A PATCH OF GRASS IN THE MIDDLE OF A PATH. THE SNAKE BELOW WAS FOUND BENEATH STONES. AN ARDUOUS SAFARI WAS MADE OVER THE MOUNTAINS FOR THE SOLE PURPOSE OF OBTAINING SPECIMENS OF THIS PARTICULAR REPTILE.

than any we were likely to encounter at higher altitudes. So, turning about, we retraced our steps for a mile or more, skidding and slipping on the steep slope as we descended.

It was necessary to clear a site among the trees by removing the dense growth of shoulder-high ferns. During this lengthy business I captured three of the little lizards (*Lygosoma m. meleagris*) which we had come to look for. None of these four-toed skinks had been taken since the discovery of a single specimen in this very valley by the British Museum Expedition of 1905, so during the following days we sought to learn all that we could about their secretive habits, found their eggs, watched the young hatching and secured a series of fifty adults.

Another desideratum was a strange, one-horned chameleon which dwells in the forest canopy and consequently seemed likely to defeat all our efforts to secure it. Only half a-dozen specimens are known. The three-horned species, named after its discoverer, Sir Harry Johnston, I found and captured but day succeeded day without news of the other. Then one morning on returning





AN ANGRY SNAKE POISED TO STRIKE AND A VELVETY GREEN TREE VIPER

THOUGH ONLY AN OPISTHOGLYPH, THE REPTILE ABOVE STRIKES SO SAVAGELY AND FLATTENS ITS HEAD SO EFFECTIVELY THAT ONE ACCORDS IT THE DEFERENCE DUE A MORE DANGEROUS SNAKE THE VIPER BELOW WAS ONE OF SEVERAL FOUND BASKING ON TOP OF SEDGES IN A SWAMP

to camp I was met with the tidings that Zachio had found a dying chameleon lying on some branches piled at the edge of our clearing, not a dozen feet from my tent Sure enough, it was the beautiful bluish-green, yellowish and purplish-brown *xenorhinus* Later we secured an example of the hornless female

In our search for skinks we came across some eggs which I recognized as belonging to a certain group of geckos (*Cnemaspis*) Once on the trail we found quite a number of the eggs, but the geckos which had laid them were living high up in the mighty forest trees Night after night, when dinner was finished, I took a flashlight and searched the trees about whose roots we had found eggs in the hope of intercepting some female descending to lay It was all to no avail We even felled dead trees and, dissecting them piecemeal, subjected every part to minute examination Then on the very day before we were due to leave, Kizamba returned from a daybreak inspection of the most promising tree with a fine adult female which he had captured on the edge of a fissure in the bark! Probably it represents an undescribed race, for no member of the genus is known from the Ruwenzori Range

We had few regrets on leaving the

NATIVES INSPECTING CORMORANTS' NESTS ON MUTANDA

AS WE WERE BEING PADDLED BACK TO CAMP ONE MORNING, MANY CORMORANTS WERE SEEN TO LEAVE SOME TREES, GROWING FROM THE CLIFF OF AN ISLET IN THE LAKE. INVESTIGATION OF THE NESTS REVEALED THAT THE YOUNG HAD FLOWN.

Mubuku camp, for the climate had been atrocious. Fine at daybreak, it soon clouded over, growing darker and darker till noon, when it was sometimes necessary to light the lamps if one wished to read or write. Then rain would fall in torrents, downpour succeeding downpour till late afternoon. So, having spent eleven days at Mubuku camp, we packed our belongings and made a forced march past fig tree ridge to a lower spot at Mihunga where the British Museum party had stayed on their pioneering zoological trip in 1905.

Here, below the forest belt, the sun shone gloriously and rodents existed in incredible numbers and variety. Day after day our traps furnished some new topotype of rat or pigmy mouse first found by Woosnam and his colleagues. We recovered pigmy mice from the stomachs of a mamba and a tree viper brought in by natives. A tree viper, named *Atheris woosnami*, was brought in and I was anxious to secure a series for study. I engaged a couple of men for several afternoons from 4 till 6 P.M. to systematically cut the ten-foot elephant grass, sedge and bush in a swamp where elephants had made a path in quest of wild bananas. This not only resulted in my capturing some of the beautiful green vipers, but also several other kinds of reptiles and amphibians whose presence had been unsuspected, though we had been camping in the vicinity for a fortnight.

One afternoon a chimpanzee climbed a lone tree on a knoll 200 yards away and watched the frog-hunting intently. Hav-

ANXIOUS BOATMEN WITH DUGOUTS FOR HIRE ON LAKE MUTANDA

ON THE MORNING OF OUR DEPARTURE SEVERAL OPTIMISTIC BOATMEN BROUGHT THEIR CLUMSY CRAFT TO TAKE US TO THE SOUTH END OF THE LAKE, A JOURNEY WHICH TOOK SEVERAL HOURS

ing reached his own conclusions about our mentality, he clambered slowly down and departed with dignity Since I had found a number of chimpanzee beds, or platforms, constructed in high trees within a mile of this swamp seeing the creature at Mihunga was not altogether a surprise, though, according to native reports, they only pass from one forest to another

Our stay on Ruwenzori had been most successful, so it was with light hearts that we returned to Bugoye to pack the collections and rearrange the loads for a fresh advance

On our arrival above Lake Bunyonyi, pitching tents seemed unnecessary, for there was a good thatched tent-shelter in addition to the gloomy and grimy little rest-house, which we avoided Since we were all very tired after a long day we thankfully had the loads moved in, building a low wall of boxes and tentage across the front of the shelter Darkness fell before we were settled in, and we were glad of our overcoats during dinner, for there was a piercing wind As we snuggled beneath the blankets of our beds little did we imagine that our awakening would be to the most miserable situation experienced during the whole safari

Our shelter, at an altitude of about 7,000 feet, faced and lay but fifty feet back from the brink of a thousand foot bluff above the lake By midnight a strong wind was carrying an endless succession of vaporous clouds over this scarp and straight into our retreat, where they condensed rapidly upon the cobweb-covered grasses on the thatch and dripped upon our nets When daybreak came

we found that the foot of every bed was soaking, for the moisture—condensing on the mesh of the mosquito nets—had trickled slowly down till absorbed by the bedding Clothes hung up the night before were sodden Nor was this all, for many grime-laden cobwebs when overburdened with moisture had collapsed as black blobs on nets, tables and chairs As if our misery were incomplete, a bleak breeze continued to blow wisps of vapor about us

After a week at Nyakabande, an exhausting climb over the mountains from there brought us to Mushungero, a rest-camp situated at the end of a little peninsula on the eastern shores of beautiful Lake Mutanda This was a truly lovely spot where the sunrises and sunsets, the papyrus-covered islets and the background of purple mountains went to form a picture not readily forgotten Mushungero was the home of an undescribed snake first found by Captain C R S Pitman, we secured a series in a short time An intelligent native, who had collected for Captain Pitman, appeared each evening with a large basket, in the bottom of which were snakes, alive and uninjured, representing his day's catch In addition, he brought several hundred eggs from half a dozen different species of snakes, though the majority were those of a harmless, frog-eating, green kind

The day after our arrival I went in a dugout in search of the local race of otter As the two boatman paddled across a lily-covered bay they pointed out a duck swimming among the pads—this I shot A few minutes later I fired at another when hey presto! up popped the enormous heads of a pair of hippopotamus not two hundred feet away. Their appearance was greeted with roars of laughter by the boatmen, who perhaps had half-expected some such sequel to the shot Just around the corner, and within half an hour of setting out, we sighted a pair of otters swimming away Paddling only when they dived, remaining low when they came up to breathe, we came within range and I dropped one with a bullet through his brain

In view of the frontier precautions in Europe, it was refreshing to find the Uganda-Ruanda frontier denoted only by a signboard inviting one to drive hereafter on the right, instead of the left, side of the road In due course we reached the small frontier village of Ruhengeri, where the customs and immigration officer was courtesy itself, he could scarcely have been more helpful in filling in the various forms, after which we were free to continue our journey to Kisenyi with a minimum of delay

Since we had been urged not to miss the opportunity of seeing the lava flow from Mount Nyamalagira while in the vicinity, we drove out from Goma (the port on Lake Kivu adjacent to Kisenyi) one morning till we found our way barred by a high bank of solidified lava two hundred yards across The lava, which was flowing beneath the crust, was pouring into the lake away to our left, and clouds of steam arose as the water boiled on coming in contact with the molten mass From volcano to lake it was flowing for a distance of twenty miles, and in places was said to be on a two-mile front A mission, native village and a coffee plantation had been overwhelmed and buried beneath the lava

SUNLIGHT AND PLANT LIFE

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THERE is an important chemical reaction in green plants that has determined and continues to determine the destiny of nations and the very existence of man This reaction takes place in light and is technically known as photosynthesis By this process carbon dioxide and water are united in the presence of chlorophyll, the green plant pigment, to form the simple sugars These products are elaborated into starch and other carbohydrates and into proteins, organic acids, fats and other plant synthates Many of these compounds are food, not only for the green plants themselves, but also for animals and nongreen plants These foods, on being assimilated, are built into new structures formed in growth and the stored energy is released

Green plants, by this process of photosynthesis, supply the living world with food The struggle for land rich in food resources has more than once influenced the destiny of ancient as well as modern people Through the centuries the availability of food has determined to a large extent the size of centers of population Transportation, to be sure, enters as an important factor, but this has been governed in general by fuel Coal beds and oil fields are resources of potential solar energy resulting directly or indirectly from photosynthesis Here again man, in his struggle for existence, battles by brute force or cunning for supremacy One is tempted to continue *ad infinitum* with examples showing the relationship of solar energy acting through the green plant to innumerable chemical and physical reactions and to the destiny of man

Solar energy received at the surface of the earth is far from being constant in value It differs greatly from time to time with respect to its *duration, intensity*, and *quality*

The length of day, or *duration* of sunlight, varies with the latitude and the season At the Equator there are approximately 12 hours of darkness and 12 hours of light for each day throughout the entire year The other extreme is reached at the poles, with 24 hours of light during the summer season and 24 hours of darkness during the winter season In intermediate latitudes the hours of sunshine fall between these extremes

The *intensity* of sunlight varies inversely as the square of the distance from the sun Since the earth's orbit is elliptical with the sun at one focus, there is a difference of approximately 7 per cent between the amount received when the earth is at perihelion in January and when it is at aphelion in July Other variations in intensity are due to the presence of dust particles and water vapor in the atmosphere An increase of 1 mm pressure in water vapor decreases the radiation intensity about 2 per cent Intensity also varies with the angular distance of the sun from the zenith, according to season and time of day Changes in actual amount of energy radiated from the sun also influences the intensity of solar energy reaching the earth's surface

The *quality* or, more accurately expressed, the wave length of sunlight also

[1] On May 1, 1929, through the initiative of Secretary C G Abbot, the Division of Radiation and Organisms of the Smithsonian Institution was established for the purpose of undertaking "those investigations of, or directly related to, living organisms wherein radiation enters as an important factor" Throughout this period important financial aid has been given by the Research Corporation of New York

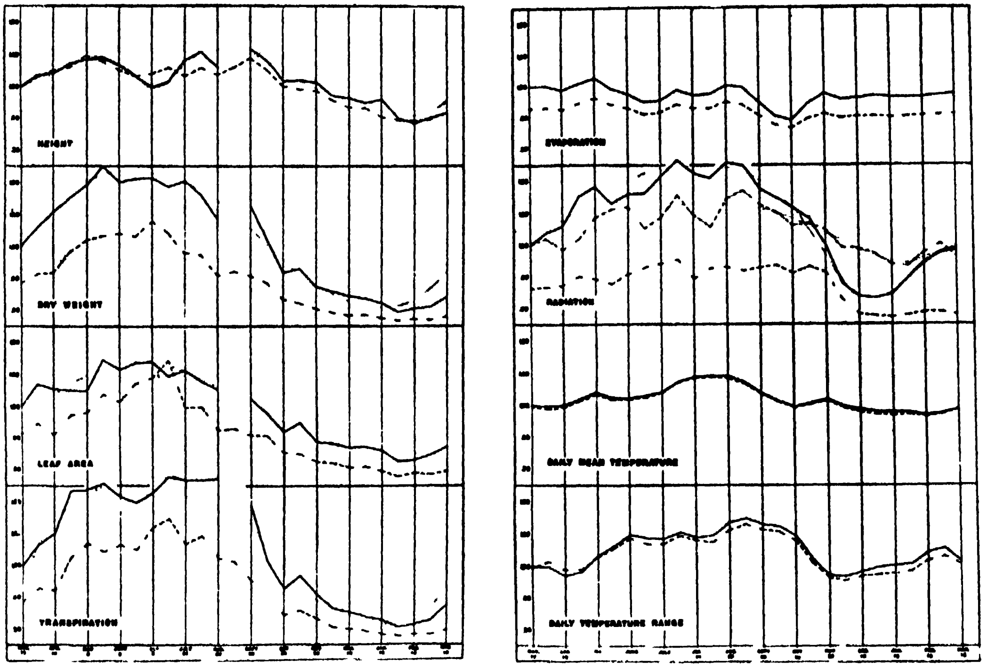


FIG 1 RELATIONSHIPS BETWEEN SUNLIGHT AND PLANT GROWTH

PLOTTED FROM THE FOUR WEEK RELATIVE VALUES OBTAINED FROM BUCKWHEAT EXPOSED SERIES ————, SHELTERED SERIES – ––––, SUNSHINE DURATION – – – – – –, SMOOTHED GRAPHS

varies The white light of the sun with the maximum energy in the yellow becomes richer in red as the sun drops from the zenith to the horizon This variation in wave-length distribution is due to the lens effect of the atmosphere covering the earth and to the differential absorption of light In the North Temperate Zone, for example, sunlight is relatively richer in blue and violet during the summer than it is in winter This is likewise true for high altitudes

No wonder a wide range in type of vegetation is encountered over the face of the earth. To be sure, temperature and moisture are important factors in bringing about this variation, but after all, variations in temperature and moisture are caused by variations in the solar energy reaching the earth

As a result of observations and studies by plant ecologists and plant physiologists, many interesting relationships have been found between light and the structure and growth of plants The brilliant colors of alpine flowers have been attributed to the presence of ultraviolet light in the clear sky of high altitudes The broad succulent leaf growth within a dense tropical forest can be attributed in part to reduced light Many interesting structural modifications in desert plants are brought about by changes in moisture and light Although such observations are interesting, little quantitative data can be obtained until plants are grown under controlled conditions.

The plants around us are continuously registering within themselves the total effects of the climate, sunlight being one of the important factors of the climatic complex Perhaps the most familiar records are those made by trees. The type of rings, their thickness and shape, give to those familiar with the language a story of the climate during the life of

the tree The researches of Douglass (1932) on tree rings have given us a most instructive picture of the climatic conditions prevailing during the past centuries.

Use has actually been made of the plant as an integrating instrument for measuring climatic conditions Johnston (1921) conducted an experiment in which the climatic conditions of a greenhouse for a period of 13 consecutive months were recorded by sets of "standard" buckwheat plants The plants were grown for 4-week exposure periods A new period began every 2 weeks Measurements of stem height, dry weight, leaf area and transpiration were made at regular intervals. Simultaneous measurements of evaporation, radiation and temperature were also obtained Two series of tests were conducted, one under ordinary conditions of an unshaded greenhouse, the other within a cheesecloth enclosure in the same greenhouse Some of these data are summarized in the form of graphs and shown in Fig 1

Although the interpretation of the plant values in terms of those derived from the instruments offers many difficulties, nevertheless several striking features of this environmental complex are registered by the plants and the instruments Attention is especially directed to the general agreement between the radiation values and those of dry weight and leaf area

These general relationships between sunlight and plant growth are interesting enough to warrant a more detailed examination by reviewing briefly the effects of the various components of sunlight upon the different physiological processes that take place in plants The sunlight here considered is actually a very small fraction of the great electromagnetic spectrum

As will be seen in Fig 2, this immense series of wave lengths extends from far beyond the short gamma waves produced from radioactive matter, such as radium, to the long wireless radio waves The enlarged portion shown below includes the wave lengths of the visible spectrum from red to violet This, together with a section in the infrared and another in the ultraviolet, comprises the wave length regions considered in the present discussion

In addition to the action of the different wave legths of light, the factors of

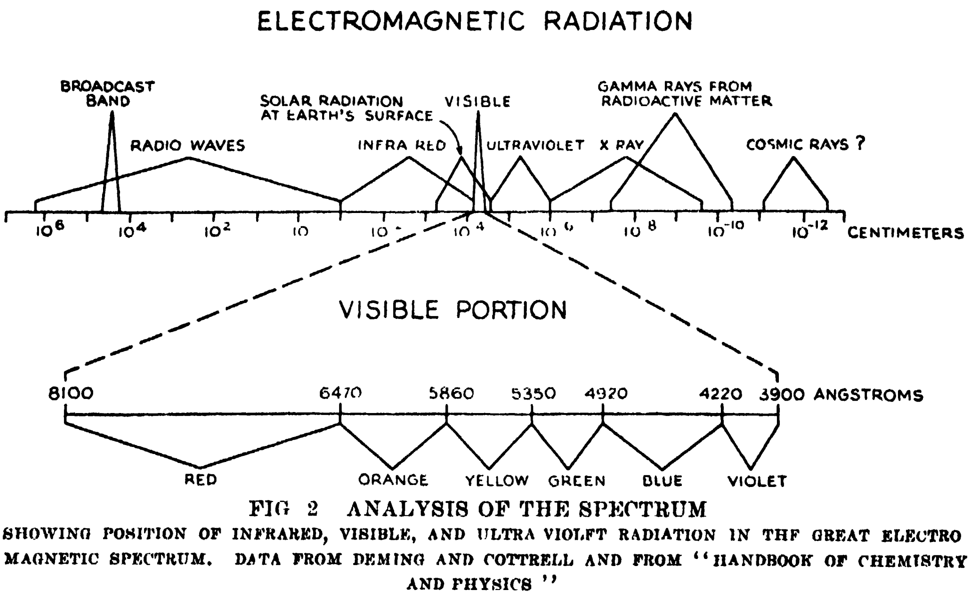


FIG 2 ANALYSIS OF THE SPECTRUM

SHOWING POSITION OF INFRARED, VISIBLE, AND ULTRA VIOLET RADIATION IN THE GREAT ELECTRO MAGNETIC SPECTRUM. DATA FROM DEMING AND COTTRELL AND FROM "HANDBOOK OF CHEMISTRY AND PHYSICS"

intensity and duration exert definite effects on the growing plant Without going too much into detail, we shall first consider some of the interesting growth responses induced by different lengths of daylight

DURATION EFFECTS

Every one has observed the remarkable regularity with which our common plants come into flowering with the advent of the different seasons Among the early blooming plants in spring are the arbutus and forsythia, then the dogwood and later the iris, and so on into the summer and fall when the asters and chrysanthemums continue the floral display Although temperature plays an important role, yet the main contributing climatic factor controlling flower production is the length of daylight Plants like the cosmos, which normally flower in autumn when the days are short, can be made to flower at other seasons of the year by artificially limiting them to definite hours of light

Numerous experiments have been carried out by Garner and Allard (1920), which conclusively demonstrate that plants may be made to produce flowers or to continue their vegetative growth by merely regulating the number of hours of exposure to daylight The lengths of the daily light and dark periods were controlled by moving the plants in and out of darkened sheds

These authors conclude from their many studies that plants which are sensitive to length of day fall naturally into two groups which are divided by a fairly definite critical light period "In the short-day group flowering is initiated by day lengths shorter than the critical, and in the long-day group flowering is initiated by day lengths in excess of this critical period . . The essential characteristic of the less sensitive or indeterminate group of plants is that they possess no clearly defined critical light period

Interesting plant responses to the length of the light period are illustrated by two experiments taken from the work reported by Garner and Allard (1925). In one of these the upper and the lower sections of a yellow cosmos plant were exposed to 10 hours of light. The middle section received light during the entire long summer days. Both the top and bottom sections of the plant responded to the characteristic short-day light exposures and soon bloomed, while the middle section remained vegetative to the long-day exposure This would indicate a localized response

In another set of experiments (Garner and Allard, 1931) artificial light was used, and the plants were exposed to this illumination for a total of 12 hours per day One group received 12 hours of continuous light and 12 hours of darkness The other groups were alternately illuminated and darkened for periods of the following durations 1 hour, 30 minutes, 15 minutes, 5 minutes, 1 minute, 15 seconds and 5 seconds Again using the yellow cosmos as an example, the interesting growth response is shown in Plate 1

A progressive decrease in height, size and weight of the plants and an increase in etiolation were noticed down to the 1-minute interval Further shortening of the light periods resulted in marked improvement in growth and general appearance All exposure intervals less than 1 hour were equally unfavorable for flowering In one of the long-day plants tried (rocket larkspur) none of the shorter alternations showed a retarding action in flowering, although the general growth responses were similar to those of the short-day plant. These are exceedingly interesting growth responses to the duration of light and to date no satisfactory explanation has been given

A most interesting method of forcing greenhouse plants has been reported by Withrow (1933, 1934, 1936) Lamps of very low wattage used as supplemental

Courtesy U S Dept Agric

PLATE 1 EQUAL ALTERNATIONS OF LIGHT AND DARK ON YELLOW COSMOS RANGING FROM 12 HOURS TO 5 SECONDS WITH DECREASE IN THE INTERVALS OF LIGHT AND DARKNESS THERE IS PROGRESSIVE DECREASE IN HEIGHT, SIZE, AND WEIGHT OF THE PLANTS AND INCREASE IN ETIOLATION AND ATTENUATION TILL THE 1 MINUTE INTERVAL IS REACHED FURTHER SHORTENING OF ALTERNATIONS CAUSES MARKED IMPROVEMENT IN GROWTH AND APPEARANCE OF THE PLANTS ALL INTERVALS FROM 1 HOUR DOWNWARD ARE ALMOST EQUALLY UNFAVORABLE FOR FLOWERING

lighting produced responses which were seemingly out of all proportion to the treatment The plants were illuminated for several hours each night in addition to the natural light they received during the day The intensities varied from less than 1 foot-candle to over 100 foot-candles In Plate 2, very little difference in flowering is noted between the aster (Heart of France) receiving 100 foot-candles and the one receiving 0 3 foot-candle Flowering even occurred with 0 1 foot-candle This was an intensity about double that of moonlight on a bright winter night at Lafayette, Ind, where these experiments were performed

The discovery of photoperiodism by Garner and Allard has attained widespread interest from the scientific as well as the utilitarian point of view The extreme sensitiveness of plants to the length of light period has been shown recently by Borthwick and Parker (1938) with Biloxi soybean plants As few as two short photoperiods were found sufficient to so change the development of the growing points that differentiation of flower primordia resulted The time of blooming was influenced by the number of photoperiod treatments Their (1938) anatomical studies also show the effect of supplemental light of very low intensity. "When plants are given an 8 hour photoperiod of natural light supplemented by 8 hours of Mazda light, initiation occurs if the intensity of the supplemental light is below 0 5 foot-candle, but does not occur if the intensity is above 0 5 foot-candle" It is thus seen that light of an intensity as low as 0 5 foot-candle or slightly higher may have definite action on the development of a plant

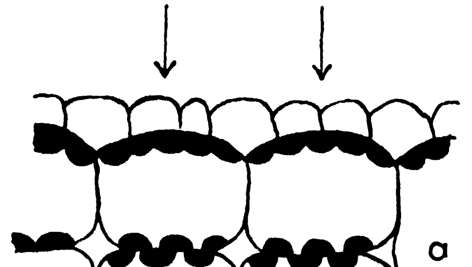
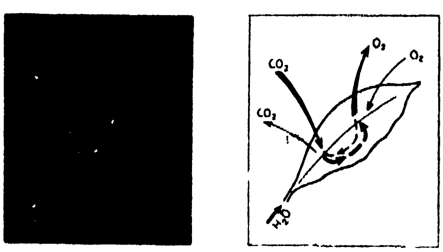


FIG 3 POSITION OF PLASTIDS IN CROSS SECTION OF A LEAF (a) IN DIFFUSED LIGHT AND (b) IN INTENSITY LIGHT ARROWS INDICATE DIRECTION WHENCE LIGHT IS COMING (AFTER STAHL)

The so-called "sleep movements" of plants, such as shown by the clover, sorrel, mimosa (sensitive plant) and *Desmodium gyrans*, are undoubtedly related to the normal daily light and dark periods. In the morning these plants open or unfold their leaves and at night close them This daily rhythm of opening and closing becomes so fixed in the protoplasm of the plants that when they are placed in continuous darkness the movement may continue for several days, each day, however, it becomes weaker until it finally ceases



PLANT METABOLISM
REPRESENTING THE EXCHANGE OF OXYGEN AND CARBON DIOXIDE WHICH TAKES PLACE IN DARKNESS (LEFT) AND LIGHT (RIGHT)

INTENSITY EFFECTS

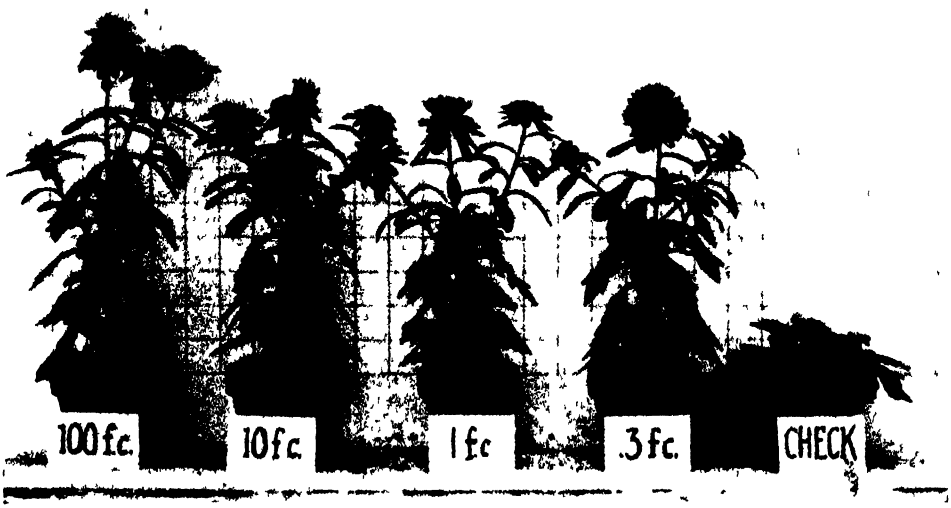
There is scarcely a place on the earth's surface either too light or too dark for plants to grow On the deserts we find plants adapted to intense sunlight. In caverns receiving little or no sunlight other types of vegetation are found. One of these "dark-loving" plants is a tiny moss (*Schistostega osmundacea*) equipped with a plate of cells forming a set of lenses capable of focusing the scattered light on its chloroplasts, those small bodies bearing the chlorophyll which is essential for photosynthesis

Many plants exposed to daylight of varying intensities have developed certain characteristic responses which in many cases have proven beneficial The English ivy (*Hedera helix*), for example, arranges its leaves in a mosaic pattern that exposes a maximum area to the light Other plants, like the compass plant (*Silphium laciniatum*) and the wild lettuce (*Lactuca scariola*), turn the edges of their leaves in a general north-south direction Thus when the light is weakest in morning and evening, the flat surfaces of the leaves are in a position to receive a maximum amount of light, whereas at noon, when the light is most intense, these surfaces are more or less parallel with the sun's rays and receive a minimum amount of direct radiation

Even the interior of leaves frequently undergoes structural changes with increasing or decreasing light intensity The microscope reveals in some instances a change in position of the chloroplasts within the leaf cells, as illustrated in Fig. 3 These chlorophyll-containing bodies arrange themselves across the path of

weak beams of light as shown in the upper figure, *a*. In strong light these bodies migrate to the side walls, thus permitting a minimum amount of exposed surface, *b*

All increase of dry weight in plants depends on their assimilating carbon dioxide from the air under the influence of light All the carbon in coal and wood, grains, oils and many other indispensable products comes, in the final analysis, from this source and depends for its energy content on sunlight In Fig 4 normal atmospheric conditions grow better and better as the light intensity is increased up to a certain value Beyond this value there is no further increase The excess radiant energy is apparently wasted so far as the process of photosynthesis is concerned One naturally wonders why it is impossible to "push" the plant in its manufacture of sugar and starch What holds back this all-important work of the plant? The answer is simple enough when the factors of photosynthesis are examined Some idea of



Courtesy R B Withrow

PLATE 2 SUPPLEMENTAL ARTIFICIAL ILLUMINATION ON FORCING ASTER (HEART OF FRANCE) INTO FLOWERING

the gas exchange between a green leaf and its immediate environment is represented It will be noted that while respiration goes on continuously in light and darkness, photosynthesis takes place only in light

Sunlight intensity varies under natural conditions from 0 at night to as much as 10,000 foot-candles on a bright summer day Most plants grow very well in intensities considerably under the high figure just noted In experiments with artificial light good growth has been obtained with intensities as low as 2,000 to 3,000 foot-candles Numerous experiments clearly show that plants under what takes place in the plant during photosynthesis may be expressed in the shorthand of chemistry

$$\underset{\text{(carbon dioxide)}}{6CO_2} + \underset{\text{(water)}}{6H_2O} + \text{light} \rightarrow \underset{\text{(sugar)}}{C_6H_{12}O_6} + \underset{\text{(oxygen)}}{6O_2}$$

The raw products that are utilized in this process are carbon dioxide and water Normal air contains about 0 035 per cent carbon dioxide. Thus one can understand that as the process of manufacturing sugar is speeded up by increasing the light intensity there will come a point at which the rate is slowed down by a lack of carbon dioxide, which at this

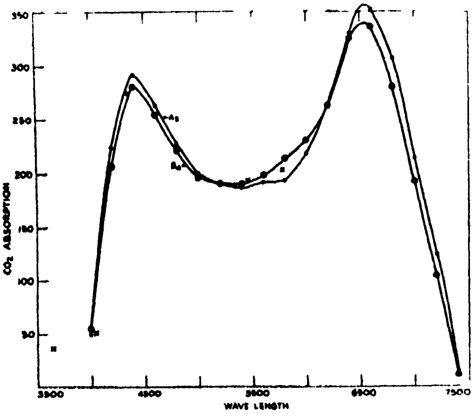


FIG. 5. WAVE-LENGTH EFFECT OF LIGHT ON CARBON DIOXIDE ASSIMILATION OF WHEAT PLANTS. A_1, THE CORRECTED FORM OF THE CURVE OBTAINED WITH THE LARGE CHRISTIANSEN FILTERS; B_1, THE CORRECTED FORM OF THE CURVE OBTAINED WITH THE SMALL CHRISTIANSEN FILTERS. POINTS MARKED X, THE RESULTS OBTAINED WITH LINE FILTERS AND QUARTZ MERCURY ARC.

low concentration flows into the plant at a limited rate. If, however, the level of the reservoir of carbon dioxide be raised by increasing its concentration in the air surrounding the plant the work done by the plant should be increased as the light intensity is further increased. This is exactly what was done in experiments with wheat (Johnston, 1935).

PLATE 3. WHEAT AT HARVEST.
AVERAGE CARBON DIOXIDE CONCENTRATIONS RELATIVE TO AIR WERE A, 3.8, B, 1.1, C, 0.9.

Three plots of wheat plants were employed in one experiment. One was open to normal air, and two were enclosed by glass cases 5 feet high with fly netting stretched across the top of each to reduce wind action. A pipe carrying a mixture of air and carbon dioxide opened into one of the enclosed plots, the other serving as the enclosed control. At the end of the experiment the growth in this carbon-dioxide-treated plot was compared to that in the enclosed control plot and to that in the open control plot.

The appearance of the three crops at harvest is shown in Plate 3. *A* received air enriched with carbon dioxide to about four times that of normal air. *B* was grown in the enclosed control plot, and *C* in the open. It was shown in these and other experiments that air enriched with carbon dioxide (1) increased the tillering of the wheat, (2) greatly increased the weight of straw, increased (3) the number and (4) weight of heads, (5) increased the number of grains produced and (6) slightly delayed the time of heading.

It is thus seen that under artificial light and sunlight conditions the process of photosynthesis may be limited by the amount of carbon dioxide in the air rather than the intensity of the light.

WAVE-LENGTH EFFECTS

Photosynthesis is, perhaps, the most important reaction in the whole world, for life itself would perish without it. On the chemical side, much remains to be done. The complexity of organic chemical reactions, the little-understood effectiveness of so-called catalysts, the behavior of enzymes, of colloids, of hormones, altogether make up a field of research of the utmost interest, but extremely complicated. It is, however, in-

teresting to examine it from other points of view

Photosynthesis takes place under the influence of light Its energy is derived from radiation The question immediately suggests itself, "What rays are utilized in this reaction?" Although many qualitative studies of this problem have been made, there is but little quantitative data on the subject, especially with economic plants Hoover (1937), of the Smithsonian Institution, has made quantitative determinations of the dependence of an important higher plant—wheat, in this case—on the wave length of light for the assimilation of atmospheric carbon dioxide He used the ingenious Christiansen filter (McAlister, 1935) to separate narrow bands of the spectrum from the beams of a group of Mazda lamps surrounding the tall glass tube within which the wheat was grown Atmospheric temperature and moisture were controlled A continuously operating device measured the change of carbon-dioxide concentration in the slow air stream which bathed the plants The effects observed depended on the color of light employed Three series of experiments were made In one, Mazda lamps with Christiansen filters were the light sources In a second series, the discontinuous line spectrum of the mercury arc combined with glass filters gave monochromatic sources In the third, sunlight itself, passing through a large-sized Christiansen filter some 60 feet from the plant, furnished floodlights of nearly monochromatic rays The results, illustrated graphically in Fig 5, were in close accord from all three series

From the data of these experiments it would appear that red rays are most promotive, blue rays second, green and yellow rays useful, while the infrared and the ultraviolet contribute nothing to the assimilation of carbon dioxide in wheat.

Somewhat similar results were obtained for the growth of a lower plant Meier (1936) grew a green alga *Stichococcus bacillaris* Naeg under equal light intensities but in four different wave-length regions Good growth, as measured by cell multiplication, was obtained in the blue, red and yellow lights, but none in the green

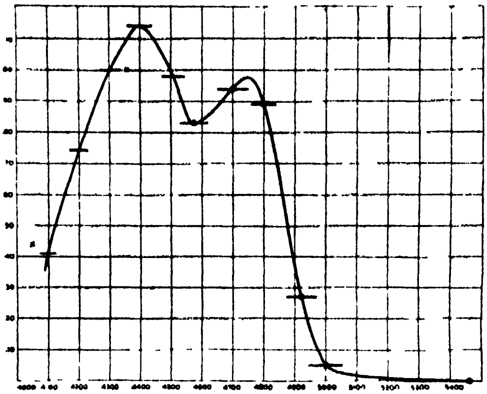


FIG 6 PHOTOTROPISM OF OAT SHOOT
PHOTOTROPIC SENSITIVITY CURVE, THE ORDINATES ARE RELATIVE SENSITIVITY VALUES, THE ABSCISSAE WAVE LENGTHS IN ANGSTROMS, AND THE HORIZONTAL BARS INDICATE THE WAVE LENGTH RANGES OF THE BALANCE POINTS

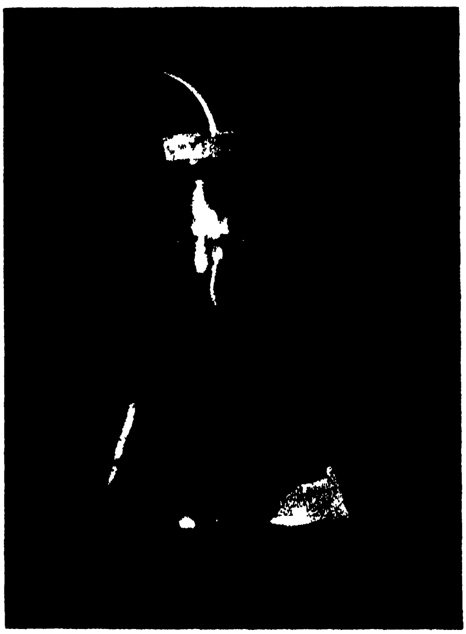


PLATE 4 OAT SEEDLING.
PHOTOTROPIC CURVATURE RESULTING FROM A DIFFERENCE IN ILLUMINATION ON OPPOSITE SIDES

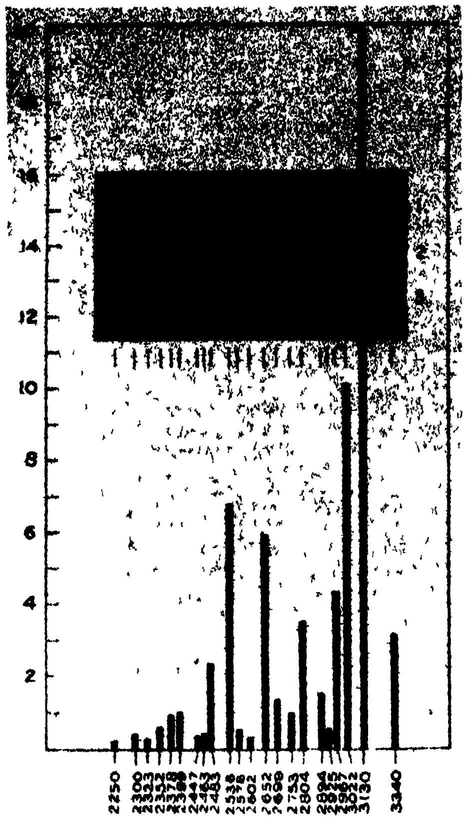


PLATE 5 AN ALGAL SPECTROGRAM.
OBTAINED BY EXPOSING A PLATE OF CHLORELLA VULGARIS TO ULTRA VIOLET RADIATION FROM A QUARTZ MERCURY LAMP FOR (1) 64 MINUTES, (2) 16 MINUTES, AND (3) 32 MINUTES. THIS SPECTROGRAM IS SUPERIMPOSED ON A DIAGRAM OF INTENSITIES (ORDINATES IN THOUSANDS OF ERGS/SEC/CM^2) OF THE WAVE LENGTHS (ABSCISSAE IN ANGSTROMS)

In the growth response of English ivy to light intensity, the leaves arrange themselves in a mosaic pattern with a maximum of leaf surface exposed to light. The leaf stems or petioles turn toward the light source. Ordinary house plants, such as the geranium, show this same response as they grow by a well-lighted window. Unless such plants are turned occasionally, the stems will grow out toward the light, giving them a lopsided appearance.

From superficial observations it would appear that light hinders or retards elongation of plant cells. It is frequently noted that the stems of many plants grow more rapidly at night than during the day. Potatoes send forth greatly elongated shoots in a darkened cellar; if these same potatoes were permitted to remain in strong light, the sprouts would be very much shorter and the internodes greatly reduced.

In the case of plants illuminated on one side it is noted that the shaded sides of the stems have stretched more than those receiving direct illumination. The uneven rate of growth on the opposite sides results in curved stems and a general appearance of the plant turning toward the light. This characteristic bending is very well illustrated with the oat sprout shown in Plate 4. Because of its convenience in handling and its ready response to light the oat seedling has been used very extensively in phototropic studies.

Although superficial observations clearly indicate that the sensitivity of the plant toward radiant energy is such that it reacts differently to light and darkness, the question as to its sensitivity to different colors or wave lengths of light is not so readily answered. To obtain an answer a plant might be placed half-way between two equally intense lights, for example blue and green, and the direction of bending noted. The plant's sensitivity to different colors could thus be determined in a general way. Such experiments have been conducted by the Smithsonian Institution to determine growth sensitivity to wave-lengths of light (Johnston, 1934).

The general procedure used in studying the wave-length effects in phototropism, as this type of response is termed, is to place an oat seedling between two lights of different color. After a time interval the seedling is examined for a one-sided growth. If, for example, with the seedling exposed to blue light on one side and to green on the other, a distinct bending was noted toward the blue light, it was then known

that the blue light exerted a greater retarding action, since the side of the seedling toward the green light grew more, thus bending the seedling toward the blue light The lights were then so adjusted as to increase the green, or decrease the blue intensity Another seedling was used and the process repeated until a balance point was obtained where the effect of one light neutralized the effect of the other in such a manner that the seedling grew vertically When this point was determined a specially constructed thermocouple replaced the seedling, and by means of a galvanometer the two light intensities were measured.

From a number of such experiments the curve shown in Fig 6 was constructed This curve illustrates the sensitivity of the oat seedling (plotted vertically) to the wave lengths of light (plotted horizontally) The sensitivity increases rapidly from 4100 A to 4400 A, then falls off somewhat to about 4575 A, and again rises to a secondary maximum at about 4750 A From this point the sensitivity decreases rapidly to 5000 A, from which point it gradually tapers to 5461, the threshold of sensitivity on the long-wave-length side Briefly, it may be concluded that the region of greatest sensitivity is in the blue That is, growth is retarded most by blue light Orange and red light have no effect in retarding the growth of these oat seedlings

Recent investigations indicate that phototropic curvatures are associated with the auxin—or growth substance—contents in the illuminated and shaded sides of the plant organs Light in some way either inactivates the auxins on the illuminated side or causes them to migrate to the shaded side, or perhaps does both, thus resulting in greater cell elongation on the shaded side. Considerable work yet remains to be done before the exact mechanism is fully understood Experiments are now in progress at the Smithsonian Institution to study more fully the exact relationship between light intensity and wave-length and growth substances found within plants

An interesting phenomenon closely paralleling phototropism has been observed for a certain type of seed germination It was found that the short wave-lengths of light—violet, blue and green—inhibited the germination of light-sensitive lettuce seed, and that the long wave-lengths—yellow, orange and red—promoted germination Flint and McAlister (1935) exposed seeds to a sufficient amount of red light to bring about a 50 per cent germination by superimposing upon them the prismatic spectrum of a Mazda light The resultant germination, as influenced by different wave lengths, is shown in the form of a curve in Fig 7

Had the seeds not been exposed to the spectrum, their germination would have been 50 per cent as represented by the horizontal dash line The germination of seeds exposed to wave-lengths lying approximately between 4000 and 5200 A was inhibited That between 5200 and 7000 was greatly promoted An interesting and heretofore unobserved phenomenon was found in the red at about 7600 A. Here also germination was inhibited Although this inhibitory region in the red has not been detected in phototropic responses, it may have been overshadowed by other effects not yet properly isolated

Experimentation has clearly demonstrated enormous differences in response of living plant tissues to different wave lengths of radiant energy in the visible spectrum When such interesting reactions occur in visible light, one becomes curious as to what effects are found with wave-lengths shorter than the visible violet and with those longer than the visible red. A single example in each of these two regions will illustrate some of the effects found

The harmful action of ultra-violet radiation is familiar to all, its painful action

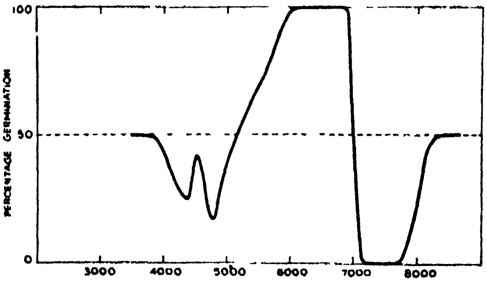


FIG 7 LETTUCE SEED GERMINATION. PERCENTAGE GERMINATION (ORDINATES) OF LIGHT SENSITIVE LETTUCE SEED IN DIFFERENT WAVE LENGTH REGIONS (ABSCISSAE) OF THE SPECTRUM AFTER AN EXPOSURE TO RED LIGHT SUFFICIENT TO EFFECT A 50 PER CENT GERMINATION

has been felt by most of us at the bathing beach after our first "outing" of the season. Its lethal action on micro-organisms has been studied by many experimenters, especially in connection with the treatment of disease. The "scare" headlines of the daily press designate it as the "death ray." Ultra-violet radiation covers a wide range of wave-lengths. These different wave-lengths have their specific characteristics just as truly as the wave-lengths in the visible spectrum.

The Smithsonian Institution has been interested in the specific action of these ultraviolet wave lengths on green algae, one of the lower forms of plant life. Using the variety *Chlorella vulgaris*, Meier (1936) has grown cultures on agar plates and exposed them to the ultra-violet spectral lines of a quartz mercury vapor lamp. The intensities of 20 different wave-lengths ranging from 2250 A to 3022 A were carefully measured and their effects studied with respect to their lethal sensitivity and to their radiotoxic virulence or speed of effectiveness in killing the cells.

An algal spectrogram with distinct areas of dead cells is shown in Plate 5. A photograph of an algal plate exposed to the ultra-violet spectrum has been superimposed on a diagram representing the intensities of the different mercury lines. Three exposures are here shown (1) 64 minutes, (2) 16 minutes, (3) 32 minutes. The wave-lengths are noted across the bottom of the diagram. The heights of the vertical bars represent radiation intensities in thousands of ergs/sec./cm^2. It was from plates and data like these that the radiotoxic spectral sensitivity and virulence were calculated. Maximum lethal sensitivity occurs at 2600 A, and there is a change of virulence with decreasing wave-length, which reached a high maximum at 2323 A.

Later studies show that a stimulative action causing increased cell multiplication of the green alga *Stichococcus bacillaris* Naeg results from sublethal exposures to the four short wave-lengths 2352, 2483, 2652, and 2967 A. The optimum stimulation point occurs for each of these wave-lengths at approximately two-thirds of the lethal exposure. The stimulative action is not transitory but has persisted in the cultures over a period of 2 years.

Next, consider a case in the near infra-red, just beyond the visible red of the spectrum. In one experiment (Johnston, 1932), tomato plants were grown under two sets of wave-length conditions. In one, only visible light was present, in the other, near infra-red radiation was added to the visible. Although the near infra-red plants were taller and heavier, their appearance was far from normal. A marked decrease in chlorophyll was apparent in the leaves and a distinct yellowing and death was noted in some cases. It appears that if this near infra-red region is not actually destructive to chlorophyll, it is of little or no benefit to its formation.

In connection with a discussion of ultra-violet and infra-red radiation effects, it is interesting to note that in the experiments of Arthur (1932) on the production of pigment in apples, coloring was increased by ultra-violet radiation, while near infra-red radiation alone or in the presence of visible light had a marked detrimental effect. Under these

rays a typical wrinkled, necrotic area soon develops

Much progress has been made in our knowledge of sunlight and the manner in which it affects plants As experimental science has improved, artificial light sources were used because their variables could be controlled better and the conditions of the experiment repeated fairly accurately In a last analysis, artificial light is modified sunlight Duration experiments can be controlled better with artificial light than with sunlight Although the intensity of artificial light is less than that of full sunlight, yet for many purposes it is sufficiently great The most vital difference between sunlight and artificial light lies in the quality or wave-length distribution An examination of the curves shown in Fig 8 may help make this point clear Compared with the energy distribution curve of solar radiation are similar curves constructed from tungsten filament radiations at two different temperatures Attention is called to the position of the maximum of each curve In the tungsten this is in the infrared, whereas in sunlight it occurs in the yellow Other artificial lights may likewise be compared with that of the sun Each shows a characteristic departure from a perfect or even fairly good match Even filters combined with artificial lights have failed to give the desired similarity It will be a distinct step forward in this type of research when an artificial light source is developed that has an energy distribution curve similar to that of solar radiation

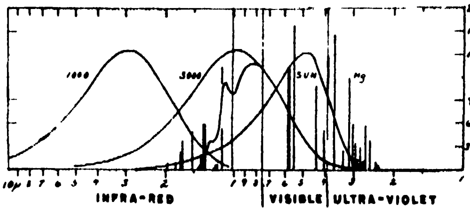


FIG 8 RADIATION CURVES
DIAGRAM OF RELATIVE ENERGY EMISSION CURVES FROM A BODY AT 1,000° K (DULL RED THERAPEUTIC LAMP) AND AT 3,000° K (HIGH TEMPERATURE TUNGSTEN LAMP) COMPARED WITH THAT FROM THE SUN AND FROM A MERCURY ARC IN QUARTZ. RADIATION FROM A TUNGSTEN LAMP EQUIPPED WITH A 1 CM WATER CELL IS ALSO SHOWN

Since plants have been growing on the earth for millions of years it is reasonable to assume that their physiology is adjusted best to sunlight Although there is experimental evidence to show that different processes go on better in some wave-lengths than others, yet the exact relationships of each should be studied separately under well-isolated portions of the spectrum With better light filters and with the construction of new light sources it is hoped to break white light into narrower and narrower spectral regions of sufficient intensity to study more accurately the many reactions that take place in the living plant—reactions upon which life itself depends.

ON THE ROCK-STRUCTURES AND PLANTS OF OLD RAG MOUNTAIN, VIRGINIA

By Dr TITUS ULKE
PATENT ATTORNEY, WASHINGTON, D C

THE mountainous region investigated comprises roughly an elliptical area, covering four by six miles, enclosing scenic Old Rag Mountain and bounded by Hughes River on the northeast side toward the village of Nethers, Popham Run towards Etlan, Robertson River toward Nicholson's Farm on the west, and by Brokenback Run on the north toward Weakley Hollow. Most of it is

now included in Shenandoah National Park

Ragged Run is a picturesque stream heading at 2,500 feet elevation half a mile from the peak and running southeasterly for about three miles into Popham Run near Etlan, and forming, at lower levels, a series of pools under gray boulders and sweet birches

The name "Old Rag" is, no doubt, a diminution of "The Old Ragged Mountain," given it on account of the rather

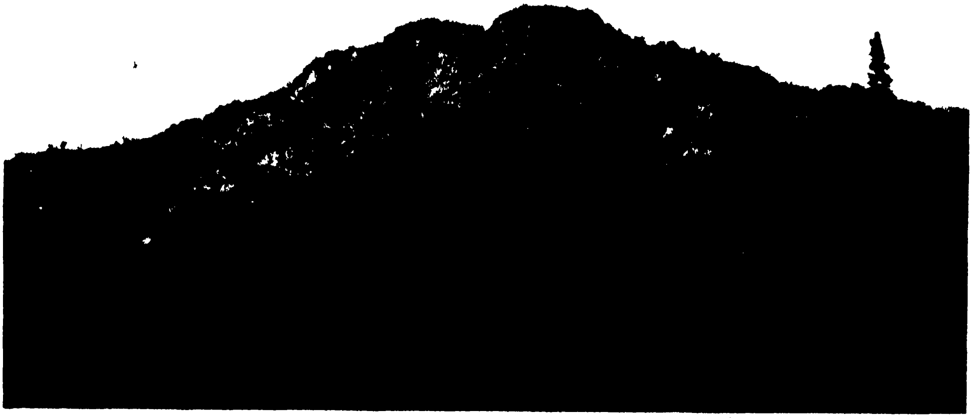


Photo by W Howard Ball

FIG 1 THE CREST OF "OLD RAG," FROM THE ROAD TO NETHERS, VA

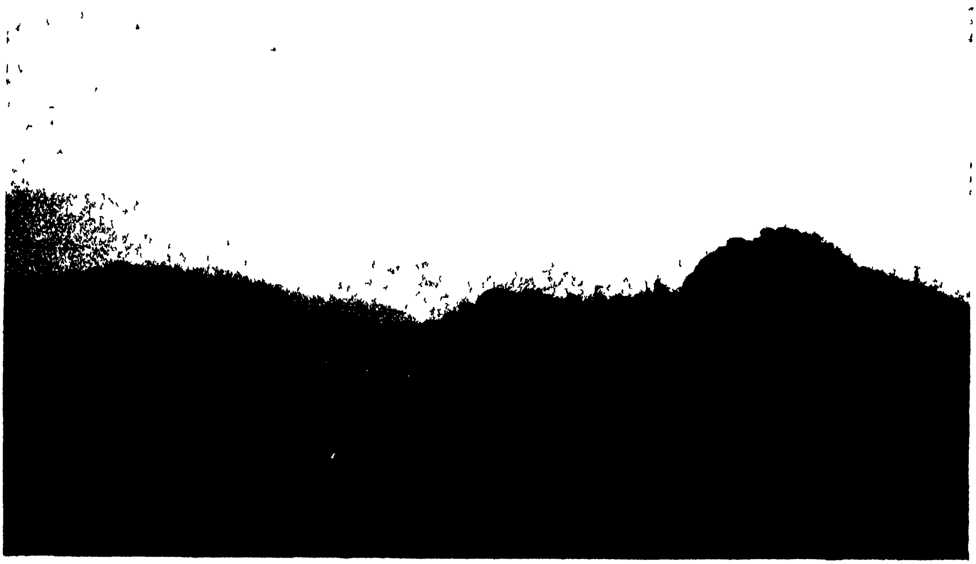


Photo by Dorothy Justus

FIG 2. DIKES OF GRANITE ALONG THE RIDGE TRAIL

ragged or frayed appearance of its long crest-line against the sky (see Figs 1, 2 and 3)

It is usually climbed by one of two well-marked Appalachian Club trails, the first, or "Ridge Trail," starting at a mile beyond Nethers at about 900 feet elevation and ascending toward the peak by a zigzag course of some three miles, eventually along the highly scenic crest-line, while the second, known as the "Saddle Trail," leads westwardly from weathered into roughly rounded blocks, as shown in Fig 4, or heaped up into weathered pinnacles and wall-like bastions of giant stepping-stones, as seen in Fig 5

At several places along the trails there may be noted veins or intrusive masses of basalt and quartzite, the quartz in the latter occasionally of a striking bluish tint, due, it is believed, to the diffractive effect of inclusions of microscopic crystals of rutile

Photo by Wm H Ball

FIG 3 VIEW FROM SUMMIT TOWARD MADISON VALLEY

the peak for a third of a mile and then drops steeply, northwesterly, for about a mile down to a road leading from the abandoned Old Rag P O to Nethers, a distance of about three miles and a drop of about 1,000 feet Nethers lies about thirteen miles by road southwest of Sperryville, Va

The backbone and all the higher points of Old Rag, which culminate in a peak 3,291 feet high, are composed of a grayish granite, which is frequently

Movement of the rock masses, especially near the crest-line, have occasioned cracking and faulting, and produced several vertical corridor-like passageways, or "couloirs," and horizontal cave-like chambers, open at each end, in which hikers may find welcome shelter from storms

Among the rather uncommon birds found flying about or nesting on Old Rag we noted the following northern raven, cerulean warbler, Bewick's wren, black

Photo by Isham W Perkins

FIG 4 THE HIGHEST POINT ON "OLD RAG"

vulture, ruffed grouse, duck hawk and chuck-will's-widow, most of which breed on the mountain, according to Mr E J Court, who has collected their eggs

A few mammals were observed, namely, the short-tailed shrew, opossum, skunk and red squirrel, as well as a few specimens of the common mountain rattlesnake

But the unusual flora of Old Rag is probably of most interest

At lower elevations giant-leaved umbrella trees (*Magnolia tripetala*) and striped maples (*Acer pennsylvanicum*) are quite abundant On wet rocks along Robertson's River on the west slope is found the long-leaved lettuce saxifrage (*Micranthes micranthidifolia*)

In the deciduous woods bordering the ridge trail at 2,500 feet elevation, and above, during last May (1939), were blooming many thousands of the lovely large-flowered wake robin (*Trillium grandiflorum*)—a never-to-be forgotten spectacle! In the saddle between the two highest summits T Ruhoff and I discovered two specimens of a unique *quintuple-flowered* variety of this beautiful trillium At about 2,500 feet elevation could be seen a number of fine specimens, in bloom, of the yellow moccasin flower and a dozen plants of an unusual *all white-flowered* variety of the showy orchis The yellow moccasin flower (*Cypripedium parviflorum*) is also found in rich soil along the road above Brokenback Run

At higher elevations along the ridge trail, in pockets of weathered granite, or peaty soil, were observed Michaux's saxifrage, rough heuchera and bristly sarsaparilla (*Aralia hispida*) At 3,000 feet elevation near the Ridge Trail occurs a solitary red spruce tree (*Picea rubens*).

On the northwest slope, immediately below the highest peak, the following

Photo by Isham W Perkins

FIG 5 BASTION OF GRANITE NEAR THE SUMMIT

plants were found associated growing in shallow sandy or peaty soil covering the granite

Mountain holly (*Ilex montana*), pigeon cherry (*Prunus pennsylvanica*), cinnamon fern, sweet fern, wild live-for-ever or sweetheart stone crop, hair sedge (*Stenophyllus capillaris*), mountain laurel, and finally, black chokeberry (*Aronia melanocarpa*)

Several of the above-mentioned plants have not been discovered as yet in the Stony Man region of Shenandoah National Park, located only five miles north of "Old Rag," while such species as the oak fern, Fraser's balsam fir, trailing wolfsbane, American mountain ash and red-berried elder have been found growing in the vicinity of Stony Man Mountain, but not, so far as is known, on "Old Rag" The chief cause for this difference in occurrence and floral preference, no doubt, lies in the differing nature and composition of the rocks and soil in the two contrasted, but adjacent, regions

Along the main crest of the Blue Ridge, as substantially followed by the Skyline Drive of Shenandoah Park, the rocks are chiefly greenstones or altered lavas, flanked on the south and east slopes by coarsely crystalline granite or granitoid rocks, such as *unakite* (epidote-porphyry) at Milam Gap and along the upper reaches of Rose River, while, as stated, granite alone forms the crest and main body of Old Rag Mountain

ORGANISM, SOCIETY AND SCIENCE

III. SCIENCE

By Dr. R. W. GERARD

PROFESSOR OF PHYSIOLOGY, THE UNIVERSITY OF CHICAGO

Now what of science in the epiorganism? That it is most responsible for the changes our civilization has undergone, and for the accelerating rate of change, there is no question Invention is the greatest national resource—the Indians on this continent did little with all that was here available to them; and the method of science, as I have put it elsewhere, "is the flowing river that deposits a rich alluvial delta of new-made wisdom It is the greatest invention of man, the method of invention " Science, alone of human achievements, is strictly cumulative and forward looking We look back to creative peaks in religion—Confucius, Moses, Christ, in art—Homer, Shakespeare, Leonardo, Beethoven; even in philosophy, but the science of Newton, Lavoisier, Helmholtz, even of the recent Michelson, Fischer and Loeb, is dwarfed by greater heights of to-day and the still more towering ones of to-morrow Newton was correct, despite his modesty, in saying, "If I saw further, 'twas because I stood on Titan's shoulders "

Of course, if science is responsible for the good, it may be blamed for the bad, and there can be little doubt that it has accelerated the specialization of units faster than the mechanisms for integration of them, with attendant org conflicts and disintegrating stresses (Even here Compton has pointed out that x-rays alone have saved more lives in the time since their discovery than high explosives have destroyed, World War included On the other hand, the obsolescence of equipment and of individual knowledge is prodigious) But though knowledge of the physical world is ahead of that of man and his societies, and new material objects, though resisted, find far easier acceptance than new ideas, still it can hardly be questioned that science will be able to produce social inventions to provide the needed integration and to control the mechanical ones.

Need I add that by "science" I do not mean the preserves of cloistered laboratory workers alone, but the collective achievement of all serious students in all fields who apply to the problems they face the tested knowledge of the past and the critical method of experimentation and evaluation Those whose "decisions are reached after due instruction in, (search for), and evaluation of the facts, pro and con; and (whose actions), while not always correct, (are) rational in the light of the evidence and, since action generates new evidence, (are) automatically self-corrective," are functioning scientifically. As Norris says, "The authority of the scientist, for his fellow men, does not consist in the vigor of his speech or writing It consists in his exhibition of the postulates of his thought, and of his objectives, and of how he came by these, and in his exhibition of his evidence, and of how he secured this."

Is the expectation that science will create effective mechanisms for better integration of the epiorganism a pious hope or a reasonable hypothesis? Our org analysis and the study of hierarchical homologies will help to answer this question I have earlier homologized the scientist in the epiorganism with the receptors of the metazoan. It is possible to go further and pair the natural scientist with the exteroceptors, which inform the

organism of its surroundings, and the social scientist with the interoceptors, which act largely via the autonomic nervous system to regulate and coordinate the parts of the organism. Surely the environment of the epiorganism is no longer only nor mainly set by its material substrate and geographical boundaries. Mental horizons, the advancing frontiers of knowledge and understanding, are now the crucial ones. Social action and evolution, like that of the organism, depend on new stimuli which emerge from the unsensed and unknown as ever more specialized receptors become sensitive to them. The scientist and his elaborate apparatus are just such an epiorgan for exploring the unknown, with increasing penetration and discrimination Leonardo said, "All knowledge is vain and erroneous excepting that brought into the world by sense perception, the mother of all certainty." And Lord Rayleigh, in an interesting address to the British Association, pointed out in detail that the apparatus of the scientist, far from superseding or opposing our common senses, merely extends them The telescope, microscope and electron microscope are modifications of the lens system of our eye, for far or close vision; the spectroscope improves our resolution of color; photography, the photoelectric cell and now television extend the spectral range and sensitivity of the retina, etc As a result of such methodological improvements, atoms, once hypothetical, are traced and counted and genes are seen and mapped.

Social Evolution

I have also pointed out the crucial and dominant role played by receptors in the evolution of axiate symmetry, over-all gradients of dominance and subordination, and of the central nervous system and its suprasegmental cortex. In view of the innumerable other parallels with the organism, in its structure, function, and history, I see no reason for doubting that the epiorganism will follow a further evolution along these same lines. Science is the mass of partially organized sense perceptions of the epiorganism, presenting to the org ever more complex problems requiring unified action. And some sort of epicortex, or brain, must be forced into existence, as living orgs have always met (by whatever mechanisms) the demands of adaptation.

The rudiments of such a social brain already exist in the philosophers and other creative artists and thinkers and in statesmen—though these latter are perhaps more in the nature of cerebellum than cerebrum. And, although President Lowell could, with some justice, cite the entomologist, Wheeler, for an honorary degree as an "eminent student of the ants, who has shown that they *also* can conduct a complex society without the use of reason," it is still true that, "To the extent that man acts rationally, he makes progress in the battle with chaos, and he and his society become more integrated and more complex Irrational behavior, directed by emotion when intelligence is uninformed or in abeyance, is sooner or later retrogressive"[8]

Not only a brain homologue, but also many other new epiorgans must be evolved by societies. How will this come about? I am convinced that the pressure of events will shape them, willy-nilly, but this does not mean that man's intelligence will not be a major instrument through which necessity operates. Remember that our reason and moral sense, like our chromosomes and brains, have themselves been created by evolution,

[8] A friendly critic states "irrationality to date has varied directly with the extension of communication." It is true that as formal education or informal education via magazines, newspapers and radio is extended to ever larger groups, it becomes watered down, but only as these groups are reached and progressively educated can they be taught to depend more on intelligence and demand more information.

have persisted and developed under the action of natural selection, and must have real survival value to the epiorganism in which, alone, they come to expression In some respects volition and choice serve for society as does gene selection for the individual; and the exercise of our best collective judgment and foresight must certainly accelerate social evolution.

For example, it is futile to point to the corruption of men by power and the prostitution of high position for selfish ends Human nature can certainly be changed in so far as standards and objectives of behavior are concerned, and many groups of men—the early Christians, the Russian revolutionaries, members of the learned professions largely—have forsworn the common goals of their day for others personally more acceptable Neither money nor prestige nor the power they beget elicit from men such effort or sacrifice as do often the motivations of love for others, self-respect, and intense conviction. It is possible to achieve on a far wider scale than at present, though it is even now not rare, the attitude toward high office that it offers trust and demands service rather than that it presents a base for plunder And, pending this, it is surely not so difficult to render such posts less attractive to the opportunist, for example, by requiring complete and permanent retirement from public or business life after a certain period in office Few adventurers sought a night as a bridegroom of the storied princess when the morning brought the executioner

More particularly for the scientists as such, some constructive suggestions for action have been voiced We must recognize first that science does not exist independently of society but under its control —is it not true that the amount and direction of research is deeply subject to the flow of funds from government (one fourth for military objectives), from industry, from the foundations and lesser donors—and that it in turn has a tremendous influence on its epiorganism Scientists are fortunately beginning to recognize and accept this responsibility [1]

And what constructive moves can scientists make to further social integration? First, perhaps, they should put their own house in order and eliminate the present unnecessarily great duplication of effort and facilities, uncoordinated experimentation and knowledge, confused and excessive publication, and the like. This can be done without sacrifice of flexibility and without a sterilizing regimentation, and fears of increasing integration and eliminating some of the existing chaos in this org are no better grounded than in the case of the greater org of society itself Bernal, in his volume on "The Social Function of Science," has presented this matter exhaustively.

Second, scientists should reestablish closer reciprocal relations with the community at large As Bragg put it, science now suggests an engine steaming ahead while the line of cars it should pull, left uncoupled, remains behind Or, in org terms, the scientist is not exercising, as he should, the gradient control which his role of receptor confers upon him. Hogben fairly points out that if the scientist reasons without action, it is partly his responsibility that wayward youth acts without reason When the org determiners are weakened, new zooids form. Popularizing science (its attitude and method and intellectual structures rather than a display of striking facts it has dug up)—"selling" science—is vital to its own further healthy development no less than to that of society Citizens educated to the intellectual virtues which science teaches—tolerance and the questioning mind, intellectual honesty, release from superstition—and possessing the

[1] Such an organization as the American Association of Scientific Workers, dedicated to the problems of science in society, is a healthy consequence.

elements of our present knowledge of evolution, genetics, psychiatry, would not voluntarily forbid free speech and reasonable social experimentation nor long tolerate a dictator who did so.

And a tradition of learning is not new nor esoteric I well recall the horror of my Vermont neighbor, whose grandparents were the first settlers in a section of this Indian infested wilderness, when I remarked, at the conclusion of an especially vivid story he passed on of frontier hardships, that probably there was no time to learn reading and writing in those hurried days In indignation he exploded, "Why, every mother taught her children to read and write as the first duty to civilization." Certainly in earliest colonial days our people demanded and received schools and seized all educational opportunities Washington's admonition in his farewell address has a prophetic ring "Promote, then, as an object of primary importance institutions for the general diffusion of knowledge In proportion as the structure of society gives force to public opinion, it should be enlightened" Government is always with the consent of the governed, but whether this consent is obtained by force or by persuasion is largely a matter of the enlightenment of the mass of people. It is because of this that government propaganda is directed to deliberate public confusion and falsification in proportion to the governors' basic dependence on force When censorship withholds the necessary facts even reason is helpless

As for further details of a program for socially conscious scientists, there are such problems calling for evaluation and solution as criteria for the selection of leaders and other functional units—capacity and vocational test devising on a far greater scale, human breeding control, as to both kind and number, positive selection and negative as well; study of the motivations of men and their origin and control via cultural anthropology and psychiatry, devising and testing new social machinery, applying the method of science to the epiorganism as it is being applied to the organism. The details of a program are less important now than that scientists, *qua* scientists, should themselves thrash through these questions and, if unable to agree on what should be done, agree at least on what investigative procedures will give sound information as to what should be done—and get them under way

Nor is it quixotic to suggest that scientists could really get action in society once they were reasonably agreed on what was desirable Bodies composed of government officials and representatives of formal science already exist and will rapidly increase, bodies which now study and will one day help guide the impact of scientific inventions on society I have elsewhere suggested the possibility of a central body, such as the National Academy of Science, controlling scientific patents It could not be very long before funds and power were built up to any desired level And, of course, a concerted refusal of scientists to contribute their services would effectively block a modern war, or dictatorship I introduce these considerations not necessarily to advocate any of the specific measures mentioned but only to emphasize that scientists need have no fear that their considered efforts at social betterment will be frustrated by lack of power Indeed, the reverse danger is greater, that organized science might obtain more power than it can yet wisely exercise.

Future of Society

And now a final word about the future of society, the further evolution of the epiorganism Unless the consistent indications of a great range of biological knowledge are all erroneous, the epiorganism will move toward increasing integration The intraorg determiners will

increase and operate further, faster, more specifically, and, especially, with greater power. Units will become more specialized and interdependent, present epi-organs will improve in function and new ones appear The individual will be more and more a part of the whole state, though it will remain meaningless to ask the question, "Does the citizen exist for the state or the state for the citizen," since reciprocal influence is the essence of an org With greater integration will come new sensitivity and more efficient and complex behavior—improved adaptive amplification

Does this, then, mean that the present totalitarian states have evolved a step beyond the more democratic ones and point our future fate or hope? I think not Note first that the democracies also have moved steadily toward integration, the accepted institutions of to-day are the socialist Utopias of yesterday, and recall, further, that living orgs deploy in many experimental ways while but few of the resultant forms survive the test of adequate adaptation Natural selection passes only the most successful products through its sieve What characteristics of Nazi Germany, for example, can be rated good or bad from the broad biological viewpoint?

The greater cohesion of the society, *per se*, is surely good. The intense nationalism produces, first, isolation and, second, overspecialization for conflict. The latter is as obviously dysgenic as the oversized tusks of the extinct sabre-tooth or the ponderous shell of the archaic king-crab Isolation and fixation of type also result from the suppression of minority (or is it majority?) opinion and the general interference with free exchange of ideas Isolation of animal stocks has always stagnated their evolution—witness the clumsy, early-evolved but long outdistanced mammals of the Australian fauna—and its consequences are even more drastic at the epiorganismic, ideational level Whitehead has stated the case against uniformity with great cogency:

> The differences between the nations and races of mankind are required to preserve the conditions under which higher development is possible. One main factor in the upward trend of animal life has been the power of wandering Perhaps this is why the armour plated monsters fared badly They could not wander Animals wander into new conditions They have to adapt themselves or die. Mankind has wandered from the trees to the plain, from the plains to the seacoast, from climate to climate, from continent to continent, and from habit of life to habit of life When man ceases to wander, he will cease to ascend in the scale of being Physical wandering is still important, but greater still is the power of man's spiritual adventures—adventures of thought, adventures of passionate feeling, adventures of aesthetic experience A diversification among human communities is essential for the provision of the incentive and material for the Odyssey of the human spirit. Other nations of different habits are not enemies, they are godsends. Men require of their neighbours something sufficiently akin to be understood, something sufficiently different to provoke attention, and something great enough to command admiration. We should even be satisfied if there is something odd enough to be interesting

The rule by force rather than by consent we have seen gives an unstable org, and the complete acceptance of the ethic that might makes right is a reversion to a superseded, and so presumably less adaptive, stage in the evolution of human and social morality, that of the paleo-thalamus rather than of the neo-cortex. And, lastly, anti-intellectualism and the prostitution of science is a deliberate gouging out of episense organs; the epi-organism so mutilated will blunder along blindly indeed Intelligence and cooperation have overcome selfish strength over and over on the testing grounds of evolution—the small cerebral mammals superseded the huge spinal dinosaurs, and a herd of elk is rarely attacked by predators. In all but its basically progressive totalitarianism, then, Germany is making an experiment which biologists

must evaluate as unsound and evolving an epiorganism that seems doomed to extinction in the struggle for survival.

But there is danger. The magnification of material power, by technological achievement, in advance of the development of adequate org controls, might lead to disruption of the whole into chaotic zooids or individuals Cro-Magnon was exterminated by a seemingly inferior race which possessed the bow and arrow; vandals might destroy civilization again as they once did under Genseric; stones from the mass had far more chance of overwhelming the Bastille than they will have of overcoming the machine guns of a tyrant's police My guess is that this will not happen, but even if it should, living orgs will again, as ever in the past, succeed in their ceaseless but winning battle against chaos and continue to evolve Whether some present forms of society remain to be modified or whether all become extinct and are supplanted by other forms, epiorganisms will advance to greater integration and better adaptation.

And in either case, the scientist and the philosopher along with the artist, the explorers and thinkers and creators, must bear the major responsibility. In the eyes of the biologist, they must be at the head of the quantitative gradient. In the words of the poet, O'Shaughnessy, which I extend to all these groups:

> We are the music makers,
> And we are the dreamers of dreams,
> Wandering by lone sea-breakers,
> And sitting by desolate streams,
> World losers and world forsakers,
> On whom the pale moon gleams
> Yet we are the movers and shakers
> Of the world for ever, it seems
>
> With wonderful deathless ditties
> We build up the world's great cities,
> And out of a fabulous story
> We fashion an empire's glory
> One man with a dream, at pleasure,
> Shall go forth and conquer a crown;
> And three with a new song's measure
> Can trample a kingdom down
>
> We, in the ages lying
> In the buried past of the earth,
> Built Nineveh with our sighing,
> And Babel itself with our mirth,
> And o'erthrow them with prophesying
> To the old of the new world's worth;
> For each age is a dream that is dying,
> Or one that is coming to birth.

THE MANY-CENTERED WHOLE

EACH man sees the world through his own eyes. It is inevitable, therefore, that there should be, in relation to knowledge, a kind of personal centripetal tendency One's own sensations, one's own point of view, one's own interests have a vividness and a validity which give them, for each one of us, an understandable priority

Choose off the shelves a group of learned treatises and sample the prefaces *Mathematics*—it is the queen of the sciences, *Physics*—it is the source of the basic laws for the behavior of all matter, *Chemistry*—a recent text says, "Chemistry touches all human interests. It is the central science", *Biology*—it assaults the greatest mystery of all, the mystery of life; *Astronomy*—it has the cosmos and eternity for its heroic theme; *Psychology*—it analyzes the mental processes which we must use on other problems; *Logic*—it deals with the laws of reason itself, *Philosophy*—it is an examination of the ultimate questions which give life meaning And so one could expand the list, with brave and startling claims for the central character and basic importance of one field, one specialty, one segment of knowledge after another . .

The web of knowledge is vast and intricately interconnected, with threads radiating in all directions in such a way as to make each fact, when one closely examines it, a veritable center. A biochemist in Holland reports something new about the symmetry of complicated molecules in certain tissues—and every cancer expert in the world focuses his attention. An American develops a method of speeding up electrified particles in a sort of glorified merry-go round—and out run the radiating and unpredictable threads of connection all over the world and throughout the whole web of scientific knowledge, touching a specialist in intermediary metabolism in New York, a physicist in Paris, an anemia specialist in Rochester, a geneticist in Russia, a cancer specialist in Boston, a metallurgist in Tokyo, a cellular physiologist in Copenhagen, a radiologist in St Louis —*Raymond B Fosdick, President of the Rockefeller Foundation, from "A Review for 1939."*

HOSPITALS AND THE ADVANCEMENT OF SCIENCE

By Dr CHAS. E REMY

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To overthrow superstition, to protect motherhood from pain, to free childhood from sickness, to bring health to all mankind, these are the ends for which, throughout the centuries, the scholars, heroes, prophets, saints and martyrs of medical science have worked and fought and died, . .

—*Yandell Henderson*

A FEW weeks ago I chanced to pick up the magazine section of a Sunday morning paper and read, for the first time, the story of Dr John Gorrie and his invention of a machine for making ice I was deeply moved by the simple tale and will attempt to recite it here, in extreme brevity, as an introduction to my paper

John Gorrie was born, of Scotch-Irish parentage, in Charleston, South Carolina It happened that he became Dr John Gorrie some years later through graduation from the College of Physicians and Surgeons of New York After a very brief period of time spent, following graduation, in Abbeville, South Carolina, he moved to, and opened an office for the practice of medicine in Apalachicola, Florida This was in the year 1833

Young Dr Gorrie arrived to find Apalachicola sunken into a veritable slough of despond as the result of an overwhelming epidemic of malaria, he found Florida, then still a territory, beginning to despair of achieving statehood because of this raging, devastating, ever-spreading fever Neighboring states were beginning to suffer from the inroads of the disease The part played by mosquitoes in the dissemination of malaria was at that time unknown

Like many of his contemporaries, this young physician was imbued with the idea that this debilitating and malicious fever took its origin and virulence from certain very noxious vapors and gases, which in turn took their origin from the lowlands and swamps Heat apparently accentuated both the vapors and their virulence, since the disease undoubtedly took on a new impetus during the warmer seasons He therefore reasoned that, if he might keep his patients surrounded by cool air, the effect from the poisonous fumes might be lessened.

For more than ten years Dr John Gorrie worked and strove with this idea. We need not list his encouragements or his discouragements In 1845 he accidentally came upon the fact, in the course of his experiments, that the lowering of the temperature of the air was but a step removed from, and in line with, the producing of ice by artificial means. The United States and Mexico were at war at that time, and every border hospital was clamoring for ice with which to cool the hospital rooms, where malaria was killing more soldiers than all the battles of the war This proved to be the added impetus which he needed to carry him onward to his goal In 1850 Dr John Gorrie demonstrated ice-making with a machine of his own manufacture, utilizing essentially the same principles of heat absorption through gas expansion, which are employed generally for refrigeration to-day

It was as a direct result of his care of the sick in hospitals that Dr John Gorrie was stimulated and inspired to the invention of an ice-making machine To-day practically each and every major industry of the world has a causal reason, in some one of its ramifications, for paying him heartfelt tribute, and millions of private homes will be his debtor for all time to come. Regardless of these facts, Dr Gorrie died on June 16, 1855, a dis-

couraged man who was quite unaware of the greatness of his contribution to the human race and toward the advancement of science

Through the medium of their inspiration to those persons employed in, or professionally associated with them, hospitals have played, and continue to play, an ever increasing part in promoting the advancement of science and the forwarding of scientific education. We have not always remembered this fact, or possibly stressed it as much as we might have done when we were soliciting in behalf of our own particular neighborhood hospital The public at large, which after all is just another way of saying "you and I," have not always remembered it when making their contribution to the local hospital or community fund drive But I am confident that the thought has not been consciously evaded by either "we" or "they" with the intent to escape the very evident inherent social and financial obligations which lie dormant in the idea It has only been due to the fact that great thoughts, great people and great achievements often walk silently and unobtrusively beside us for long periods of time unrecognized and unsuspected To an unusual degree has this been true of hospital achievement and influence It is time for the world to awaken

Hospitals typify one of civilization's most modern, as well as most lauded concepts, that of accomplishment through group cooperation Hundreds and sometimes thousands of individuals in a single hospital go daily about their varied, yet particular and specific duties in different parts of the hospital; simultaneously, in nearby or in distant portions of the institution, they perform seemingly quite unrelated acts and tasks; yet all collaborating none the less, as parts of a carefully coordinated whole, in contribution toward the final end result, that some John Doe, of whom most of them have never heard and may never hear, shall be saved from invalidism or death

The modern hospital has become a complicated managerial and administrative problem by reason of its many facets, by the fact of the very multiplicity of its activities Of no other institution in the world can it be more aptly remarked that it is made up of wheels within wheels Nearly every one of them is a very plain, simple little wheel, but there are so many of them, and all different The administration of a bath by a nurse to a patient is not in itself inherently a very complicated procedure, neither is the administering of the medicines which may have been prescribed, nor the sweeping of the floors, the washing and ironing of the linen, the making of beds, the shoveling of coal, the preparing and cooking of food, all these things are but simple routines The distribution of alms in one form or another, the keeping of the account books, the purchase and disbursement of supplies, the collection of bills, the maintenance of records, are all such ordinary activities as to be familiar, for the most part, to almost every adult man and woman. There is nothing awe-inspiring or gruesome or mysterious or complicated or superstition-stirring about any of these activities, which constitute the bulk of hospital work To the physician, the surgeon, the pathologist, the pharmacist, the laboratory or x-ray technician, the anesthetist or the nurse, their various respective routines have become just as common and prosaic through frequent and multiple repetition Yet all these many and varied and simple routines, seemingly so unrelated, actually so closely knit into the essential pattern of hospital efficiency, have not only served to develop and to maintain for hundreds of years a certain sense of awe and mystery in relation to the thought of a hospital, but have in addition thereto somehow managed to exert a forceful influence in behalf of the forward trend

of civilization itself, including its handmaiden science.

Hospitals, from times almost immemorial, have consisted of, or been constituted by, an army of men and women, each age or era contributing its quota as troop or regiment or battalion, of that army, an army so great and so vast in the total aggregate as to appear numberless and unending, an army which has never retreated, which faces always forward toward the enemy, and which marches ever on and on, its beginnings lost in the intangible mists of the infinite past, its destination equally undiscernible in the hazy distances of an even more infinitely distant future It is an army composed and made up of physicians, maids, dietitians, chaplains, nurses, seamstresses, cooks, orderlies, hospital trustees, priests, porters, scientists, day laborers, clerks, hospital superintendents, ambulance drivers, waitresses, health department officials and personnel, boards of public welfare of great cities, laundresses, social service and medical social service workers, engineers, electricians, scholars, savants, nuns, plumbers, pipefitters and other classifications too varied and numerous for mention It is an army girt for service, for battle, self-sacrifice and travail It is an army all members of which have dedicated their lives and works to the aim and end that disease, if not death itself, shall finally be made "*to vanish from the earth*"

A great forward step was made in the outlook for hospitals and their coworker science, with the advent into the former of the physicians' private patients, and conditions improved very rapidly thereafter It gradually became apparent that every up-to-date facility and scientific aid to diagnosis and treatment could be grouped together in the hospital and thus be made available to all physicians and their patients; facilities and equipment ordinarily quite beyond financial reach of the large majority of physicians as private office equipment. Confidence in the merit of hospital service took on a greater solidarity, and as this developed and grew larger in the minds of doctors and patients alike, step by step new innovations were made; pathological and bacteriological laboratories were added; one by one x-ray, dietetic and other special services took their place in the hospital ensemble; interest in the scientific investigation of disease processes and their causal factors became tremendously stimulated It was inevitable that ultimately the scientific minds of the entire world began to visualize and finally grasped a comprehension of the latent possibilities of hospitals as a fertile field for the advancement of science not only in relation to the human body, but in relation to the welfare of all mankind, and the preeminent evidence of this may be remarked in the ever growing and closer affiliation between hospitals and the more important colleges and universities.

It is impossible to garner here examples showing how the hospital has inspired men to scientific discoveries and inventions in almost every known field of research and forward-looking achievement. The one isolated example of Dr. John Gorrie has been cited from many thousands of similar individual services to science and mankind which have taken their germination from inspiration supplied by hospitals. Time does not permit mention of others. Viewing hospitals in perspective, however, our subject may not rightly be abandoned without stressed mention of one of the special divisions of these wonderful institutions.

The hospital laboratory, with its batteries of scientific apparatus and instruments of precision, has probably done more than any other one factor, in or out of the hospital, to relegate empiricism and the trial-and-error methods of yesterday, to the rearmost shadows of that great humanitarian stage, known as the practice of medicine, whereon there is

daily played, all over the world, the never-ending drama of life and death. The hospital laboratory is a domain wherein the microscope, both figuratively and actually, holds the center of the stage. To those who will look carefully it reveals the existence, around and about them, of another fantastic and seemingly infinite world, crowded and teeming with life, in the midst of which mankind lived for hundreds of thousands of years, totally unaware and unsuspecting of its existence; a universe within a universe, containing myriads upon myriads of living creatures which eat and drink and reproduce their kind and fight and die, but which are so small that a colony made up of many thousands of them might veritably rest upon the point of a needle and thereon remain invisible to the unaided human eye; creatures differing as widely in their types of form and structure and in their habits and customs as the various members of that larger, visible animal and vegetable kingdom of which we ourselves are an integral part, armies of builders and armies of wreckers, each as energetic in its respective realm as Maeterlinck has so vividly pictured the busy bee, groups with potentialities for good and groups with potentialities for evil, so immeasurable in comparison to those same traits as found in man and his brother animals of the visible world, as to cause these latter to fade into pale insignificance

The hospital laboratory has become the chemical warfare and intelligence divisions combined of that world-wide army which is devoting its energies to the fighting of disease, pestilence and death. It is at one and the same time a sentinel ever on guard to warn of the approach of stealthy or unsuspected foes, a prompt and efficient scout and messenger to give word of the battle's trend, a powerful telescope to render visible the approach of an attacking enemy while the latter's armies yet remain indistinguishable to the unaided human eye; and a factory for the manufacture of munitions of war, with which to put the armies of dread disease to rout The laboratory as the secret intelligence and research bureau serves not only in the formulation of plans and campaigns against the enemy, but likewise for the discovery and development of those mysterious and marvelous deadly chemical formulae, through the discovery and later dissemination of which the foes of life and health are slowly, one after another, overcome or held at bay pending reinforcements from the same trustworthy source. It is a citadel of offense and defense, and it is quite commonly the final determining factor as to whether the besieged shall repulse the enemy or be overcome in the battle and perish

Physicians, chemists, engineers and others of the hospital field have given many discoveries to the world, ranging in level of importance from insulin, for protection of the diabetic, to devices as simple or simpler than the humble safety pin The friends, relatives and patients of the one or the other, inspired by hospital needs or hospital aspirations, have likewise contributed their quota In the outlook of the laboratory alone the vistas of possibility are beyond the realms of comprehension. As the modern packing-house industries have gradually found use for nearly all of what were formerly, at one time, the waste products of those industries, so, many fold over, are the possibilities in the outlook of our hospital laboratories Latent in every one of those many thousands of organisms which inhabit that world which was opened up to man by the microscope, lie possibilities for discoveries of wonderful and stupendous import to science; who knows but from that wonder-land which they inhabit, the secrets of life and death themselves may not some time be wrested. The potentialities of the contributions of hospitals toward the advancement of science have only been faintly scratched; the forward march has only just begun.

BLUE JAY: BRIGAND OR BENEFACTOR?

WHAT DID THE BLUE JAY DO WITH THE NUT?

By Dr. ARNOLD GESELL

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IT took place on a bleak autumn afternoon (November 21) in New England in a thickly settled residential district on a street busy with automobile traffic It concerned an urban squirrel and a metropolitan blue jay in swift sequence as follows At 1 45 a gray squirrel, answering my tapping signal, ran up a rustic incline which leads to a window box, to secure a nut (papershell pecan) which I offered him through an open window At 1 46 this squirrel scampered back to the lawn to a point about 15 feet away He buried the nut and raked a brittle oak leaf over it At 1 47 the squirrel returned to the window box for a second nut Immediately a blue jay flew down to the precise spot where the first nut had just been buried, pecked vigorously through the oak leaf into the soil, and in about 30 seconds seized the nut in his bill and disappeared with swift and sudden flight into a towering elm near by

I had no wish to worsen the reputation of the blue jay, but his alertness was so clever and his acquisitiveness so adept that I reported the incident in a brief note to *Science*[1] Somewhat venturesomely I included the question, "What did the blue jay do with the nut?"

This question evoked such interesting responses from varied observers that a summary report in SCIENTIFIC MONTHLY now seems in order. Whether such a summary will place the blue jay in a more favorable light, the readers will judge for themselves Meanwhile we shall quote with approval the November 13, 1858 entry in Thoreau's Journal· "It is the more glorious to live in Concord because the jay is so splendidly painted"

On the evidence now available any one of the following possibilities deserves consideration

1 The blue jay ate the nut

2 The blue jay cached the nut as a thrifty investment to be eaten at a later date after frost and moisture had softened the shell

3 The blue jay cached the nut, the squirrel retrieved it and ate it In which event, it has been suggested an old adage again applies, "He laughs best, who laughs last"

4 The blue jay planted the nut, and it grew into a beautiful tree!

5 The blue jay ate only part of the nut, dropped most of the kernel which was eaten by a beneficent species

1 The blue jay ate the nut. This possibility is vouched for by Thoreau himself in a passage of his Journal (November 10, 1858) which tells us clearly how the blue jay accomplished the feat·

> Hearing in the oak and near by a sound as if some one had broken a twig, I looked up and saw a jay pecking at an acorn There were several jays busily gathering acorns on a scarlet oak I could hear them break them off They then flew to a suitable limb, and placing the acorn under one foot, hammered away at it busily, looking round from time to time to see if any foe was approaching, and soon reached the meat and nibbled at it, holding up their heads to swallow, while they held it very firmly with their claws (Their hammering made a sound like the woodpecker's) Nevertheless it sometimes dropped to the ground before they had done with it

This, however, is not an invariable method of eating. A correspondent, a psychologist, from Mississippi, frequently finds shells of nuts, with

[1] Volume 89, p 35

meats mostly extracted, wedged in cracks of fence posts or in the crotch of branches It appears that natural cracks, chinks and pits serve as holdfasts for the nuts which are pecked by the blue jay W E Ritter has noted this behavior in the acorn storing of the California woodpecker. He also remarks that the California jay is almost as devoted to oaks as is the woodpecker, but finds that the jay typically buries the nuts in the ground for future use

Another correspondent, a pharmacologist, also from Mississippi, corroborates Thoreau "I have frequently seen blue jays pluck the nuts (pecans) from the tree and fly with them in their bill to a limb of the same tree, and while holding the pecan nut on the limb with the claw of one foot, vigorously pick the nut open with the bill and devour the contents"

A correspondent, a pharmacologist from Tennessee, reports that blue jays as well as crows infest the wild pecan trees near Memphis and consume great numbers of the nuts Many times he has observed a blue jay perched on a limb cracking the nuts by hammerlike blows of the head This is after the manner of woodpeckers, but the jay holds the nut in his bill and pounds the nut against the limb or stump, which serves as an anvil (The director of the Texas Agricultural Experiment Station has observed that a blue jay after pounding a nut against the trunk of the tree deliberately dropped the nut to the ground, recovering it and dropping it two or three times, perhaps with the object of letting the fall break the hull "The dropping did not appear to be accidental, as the bird dropped the nut each time immediately after picking it up.")

"Furthermore," continues our Tennessee observer, "the blue jays will literally riddle an oak tree of its acorns, even when the acorns are between a half and three quarters of an inch in diameter, and scarcely easier to crack than a pecan . . I therefore," adds this correspondent, "feel no hesitation in worsening the reputation of the blue jay"

In similar vein, a plant pathologist of the United States Department of Agriculture from the Pecan Field Laboratory in Georgia

I wish to inform you that the blue jay is Public Enemy No 1 of the pecan industry throughout the South, especially the Schley, which is a very thin shell variety We estimate that in some instances blue jays destroy one pound of pecans daily Not that they eat this many but they carry them off to some nearby evergreen tree such as magnolia or live oak and pound them against the limbs while holding the nut in their beaks In most instances these nuts fall to the ground and the blue jay flies away for another nut Therefore the ravages of this bird causes the pecan growers to patrol their orchards with shotguns and a large number of these pests are killed every year in the South in this manner In my opinion it is impossible to worsen the reputation of Mr Blue Jay down here, although we all think that he is a very beautiful bird

2 and 3 The blue jay cached the nut—to be eaten later by himself or by a squirrel! With respect to these two possibilities, our data are meager but suggestive It seems that squirrel and blue jay are at more or less constant war with each other, even in Chicago A correspondent from that city reports that when a squirrel in his back yard had cached a peanut, two blue jays watchfully circled overhead and then swooped down and got the nut This happened several times But on a later occasion the squirrel "pretended" to bury the nut in one or two places before actually burying it in a true cache When the jays came down to a false place they screamed, but by persevering they finally retrieved the cached nut

There can be no doubt that the urban squirrel before hiding a nut often displays an indecisive kind of behavior which resembles feigning Is this a ruse—a protective expedient against excessive robbery by blue jays?

One correspondent reports the performance of two gray squirrels who

showed no such cunning. These, however, were wilderness squirrels without any Chicago background. In Berkshire midwinter over a period of thirty minutes or more individual peanuts were fed alternately to the two gray squirrels Each time the squirrel promptly stored the nut in the recesses formed by the loose bark of a hemlock tree. No sooner stuffed away, the squirrel came back for another nut. "But spying from above unobserved and relentless was the culprit blue jay, recovering each nut No time to fly away, no chance taken of missing a morsel; every one devoured . . . I mourn," says the correspondent, "about adding fresh insult to the jay, but not more so than over the stupidity of the gray squirrel"

Coming back from wilderness to metropolis, we have the honor to report a confirmatory observation made by William Beebe from the west window of his Tropical Research Laboratory in the New York Zoological Park The window opens on an extent of lawn enclosed by shrubs and trees

> This is a favorite place for the nut caches of gray squirrels Scores of acorns are buried, some within a yard of the window
>
> This last autumn at least two blue jays have systematically robbed the squirrels One bird which I watched perched in a nearby tree Within two minutes after a nut was pushed down and covered up by a squirrel, the jay was on the spot, and soon unearthed the acorn It then flew up, perched for a few seconds, then returned to another part of the lawn, and jammed the nut into the ground, driving it home with repeated blows of its beak This happened at least four times within an hour, and perhaps oftener Two jays repeated this performance many times within a period of several weeks

For similar reasons, Mable Osgood Wright is compelled to compare the blue jay with a robber baron and indeed calls him the "azure-plumed jeering bandit" However, she thinks that the squirrels in the end have decidedly the best of it, for they frequently find the very holes where the jays have hidden their plunder!

4. The blue jay planted the nut and it grew into a beautiful tree! For this theory we have no less an authority than Thoreau and Forbush's monumental monograph on the birds of New England, published by the Commonwealth of Massachusetts By burying nuts and seeds blue jays rear forests In a few years these birds can replant a stretch of cleared land They reforest not only by regurgitating and eliminating seeds and by dropping nuts while feeding or in flight, but by actually tamping them into the ground.

Thoreau was led to investigate this very matter in the autumn of 1860, just after Emerson had planted a lot with acorns. Says the Journal of Thoreau:

> I have come out this afternoon to get ten seedling oaks out of a purely oak wood, and as many out of a purely pine wood and then compare them
>
> As I am coming out of the pine wood, looking for seedling oaks, I see a jay which was screaming at me, fly to a white oak 8 or 10 rods from the wooded pasture and directly alight on the ground, pick up an acorn, fly back into the woods with it This was one, perhaps the most effectual, way in which this wood was stocked with the numerous little oaks which I saw under that dense white pine grove Where will you look for a jay sooner than in a dense white pine thicket? It is there they commonly live and build . . .

Squirrels and jays may be enemies, but in reforestation Thoreau concludes both serve man· "So far as our noblest hardwood forests were concerned, the animals, especially squirrels and jays, are our greatest and almost only benefactors It is to them that we owe this gift"

5. The blue jay fed the bobwhite with the nut This is our condensed version of possibility number five, though here the pecan is symbolic of the acorn, and the bobwhite is specifically a habitant of Walker County, Texas Our authority is a most interesting investigation, under the auspices of Walter Taylor, senior biologist of the Texas Cooperative Wild Life Research Unit, United States Department of Agriculture. Two of his

field biologists (Lay and Siegler), aware that the acorn is a favorite food of the quail, made a quantitative measurement of jay activity to determine whether there was any connection between the food habits of the jay and food availability for the quail It seemed extremely doubtful that the few squirrels and the hogs (one hog per 69 acres) could supply sufficient mast for the quail.

Census and estimates showed one blue jay to every 313 acres; and a crop of 42,000 acorns for a selected red oak, and 100,000 acorns for a water oak The jays not only plucked off acorns to fly away with them, but picked them off, and pecked at them dropping particles, so that the ground beneath the tree was strewn with pieces of acorn Actual count and calculation showed that 11,400 acorns of the red oak and 26,000 of the water oak were made available to quail by jay. These numbers are so great that the blue jay is adjudged to be "very likely the most important link between the acorn and the quail in woodland type as exemplified in Walker County, Texas"

If the blue jay needs a feather in his cap, this biological linkage must not be overlooked However, there is little danger that the blue jay will suffer any injustice He has so many admirers Even the informed ornithologist who sets him down with the crow as being in general an injurious species, is likely to regard him as an engaging rascal There is such a strong sentiment in favor of him "due to his interesting personality" that the Audubon societies and nature lovers keep him off the blacklist of birds excepted from the protection which is offered desirable species. Audubon himself characterized blue jay (*Cyanocitta cristata*) as "one of our commonest, wisest, most beautiful birds." Even if he is a sort of Ishmael among feathered tribes, he is, insists Wilson Flagg, "a true American He is known throughout the continent and never visits another country."

What if he is the bad boy of the bird neighborhood and the terror of small birds?—so runs the apologia, "He is also a devoted husband and father who shows his best traits in the family circle." Forbush even notes that blue jays care for the aged and infirm. He cites an observation which "tells of an old, worn, partially blind blue jay that was fed, tended, and guarded by companions who never deserted him They guided him to a spring where he bathed regularly, always with some of his companions close by him"

Despite his cannibalistic fondness for eggs and nestlings, does he not also eat injurious creatures such as the hairy caterpillar, gypsy moth, brown tail, tent and sphinx moths, fruit-feeding beetles, and grasshoppers? And despite his audacious insolence is there not "a dashing reckless air about him that makes us pardon his faults?"

The scream of the jay to the poet-naturalist of Concord was a true winter sound "It is wholly without sentiment and in harmony with winter."

Ah, but the blue jay is more than a strident screamer In exalted moods he becomes a ventriloquist, capable of exquisite mimicry For this we have the high testimony of Dr P L Hatch A blue jay was singing and "the notes which fell in showers like dew drops, almost inaudible, were among the clearest, most delicate, sweet and melodious that ever found their way into a human ear. I was in an ecstasy of wonder and surprise . . . If a diet upon canary brains and mocking birds' eyes can afford such inspiration, these songsters contribute as much in their deaths as in their lives, and the regally plumed blue jay should live forever."

GENERAL FORMAL EDUCATION BY FIELD OF EMINENCE

By Dr. MAPHEUS SMITH

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UNDIFFERENTIATED data such as those presented in a recent study[1] are of unquestioned value for general discussions of the relationship of social prominence and general formal education, but mass data always hide so much that is significant that the effort required to analyze the general population into its component populations according to significant characteristics is justified. One of the most important characteristics is field of eminence or vocation, concerning which contemporary information as well as a small amount of material on trends over the last quarter of a century are available The present paper is thus an extension of the discussion of general formal education by separate consideration of data on some important fields of eminence

Table I contains the most recent data available from "Who's Who in America" The medical profession stands out as the only group all members of which report an equivalent of a college degree, compared with only 72 4 per cent college graduates for the entire group who reported adequate educational data Next in order were educators, chemists, army and navy officers, geologists, clergymen, other scientists, lawyers and technical engineers, each with more than 72 4 per cent of its members college graduates. The smallest percentage of college degrees was held by persons prominent in art (8 5), but almost three fourths had attended art schools. Actors and other persons prominent in the theater and motion pictures had almost as poor a record of college graduation (8 7 per cent.) and had less formal education than any other group, 41 7 per cent having completed their formal schooling in the grades

Prominent musicians also prove to have had a smaller than average amount of college training Music school or college training was reported by about three fourths of them, however. Editors and newspaper writers, business men, writers, agriculturists and public officials have received considerably less formal education than the total group The artistic groups are thus below average in formal education and the professions are at the other extreme And persons in such practical pursuits as business, newspaper work, agriculture and public office are between the other two groups, although more similar to the former

TRENDS

So incomplete are data showing changes in educational background for different sorts of leaders that the best procedure will be a separate review of the information for each field of eminence. In *authorship* it appears, according to one line of reasoning, that formal education has not made very rapid progress in the United States, especially for persons of highest quality Clarke's important study of prominent American writers born before 1850 disclosed that 55 5 per cent. of those whose education was known had completed the college course, and an additional 16 4 per cent had attended college Only 15 3 per cent had never reached secondary school, and only 4 per

[1] Mapheus Smith, SCIENTIFIC MONTHLY, 46. 551–560, 1938.

TABLE I

PERCENTAGE OF PERSONS LISTED IN "WHO'S WHO IN AMERICA" REPORTING DIFFERENT TYPES OF EDUCATIONAL BACKGROUND, CLASSIFIED BY FIELD OF EMINENCE, 1934[a]

Occupation	Total No	No with sufficient educational data	Percentage: Total	Only common school education	Secondary school education	Art school education	Music school education	Non-graduates of colleges	College graduates
Authorship	2,058	1,983	100 0	14 2	11 5	1 4	0 0	22 0	50 9
Journalism	1,269	1,248	100 0	14 0	11 5	1 0	0 0	24 9	48 6
Art	924	859	100 0	6 3	2 3	76 4	0 0	6 5	8 5
Music	483	403	100 0	12 7	10 4	0 0	38 2	17 4	21 3
Theater and motion pictures	158	127	100 0	41 7	23 6	6 3	0 0	19 7	8 7
Chemistry	215	215	100 0	4	1 9	0 0	0 0	5 6	92 1
Geology	116	116	100 0	9	9	0 0	0 0	9 4	88 8
Other science	491	490	100 0	3 1	1 6	4	0 0	7 1	87 8
Technical engineering	927	914	100 0	4 2	4 2	1	0 0	14 6	76 9
Medicine	1,988	1,988	100 0	0 0	0 0	0 0	0 0	0 0	100 0
Religion	2,849	2,835	100 0	8	9	04	0 0	9 7	88 54
Education	6 013	5,998	100 0	3	5	5	0 0	1 8	96 9
Law	3,789	3,743	100 0	3 9	3 2	0 0	0 0	10 6	82 3
Public office	1 341	1,314	100 0	12 1	9 7	0 0	0 0	19 0	59 2
Army and Navy	506	493	100 0	2 4	2 4	0 0	0 0	4 1	91 1
Business and industry	5,810	5,521	100 0	16 8	15 3	2	0 0	17 9	49 8
Agriculture	314	309	100 0	11 0	13 6	0 0	0 0	20 1	55 3
Miscellaneous	1,830	1,779	100 0	7 1	7 1	2 3	0 0	16 0	67 5
Total	**31,081**	**30,338**	**100 0**	**7 0**	**6 1**	**2 6**	**0 5**	**11 4**	**72.4**

[a] Compiled from tables in "Who's Who in America," 1936–37, pp 2706, 2708

cent had never completed the grammar school course.[2] Even in 1934 only 72 9 per cent of the prominent writers had attended college and 14 2 per cent had never attended secondary school

However, it is reasonable to believe that Clarke's and the "Who's Who in America" data are not closely comparable. Clarke's data distinguish various kinds of writers not included in the more recent classification He subdivided his subjects into patrons, librarians, actors, orators, publicists, narrators, erudite writers, popularizers, speculative writers, prose writers, poets and dramatists In the first four groups there were too few individuals to make the classes statistically significant But for publicists about as large a proportion of persons had college education as was true for the group as a whole For narrators the college group was smaller than for the average of the whole group Erudite writers were above the group averages in college education, as were the popularizers The speculative writers were even further above the average in college education. Prose writers and poets had a smaller than average proportion with this level of training Thus the types with most college education, in order, were speculative writers, popularizers and erudite writers,[3] two of which classes, speculative and erudite writers, do not appear among the "Who's Who in America" authorship group It is therefore safe to assume that the educational level of Clarke's group was raised by the inclusion of a number of persons who were both writers and teachers or who com-

[2] E L Clarke, "American Men of Letters, Their Nature and Nurture," *Columbia University Studies in History, Economics and Public Law,* Vol 72, 1916, p 67 Alfred Odin's prior study of French literary figures should also be mentioned He reported that about 98 per cent. had education of the level of what was college grade in the United States Compare Odin's "Genèse des Grands Hommes," Paris, 1895, pp. 526–27, with Lester F Ward's "Applied Sociology," New York, 1906, pp. 216–219

[3] Clarke, *op cit*, p 67.

bined writing with professional interests. For a group including only the sort of writers embraced in the "Who's Who in America" classification Clarke's subjects, therefore, might be expected to have reported less formal education. What adjustment would have to be made can not be determined, but this line of reasoning suggests that the literary group of the present generation does have a somewhat larger proportion of college-trained persons than in earlier generations In support of this argument is evidence from the first edition (1899) of "Who's Who in America" At the turn of the century only 27 per cent of the authors reported college graduation.[4]

Prominent American *editors and journalists,* on the whole, have shown a considerable gain in educational status during the last third of a century. Of those first listed in "Who's Who in America" only 33 per cent had completed college.[5] In comparison, 45 3 per cent of the editors and newspaper writers added to the list in 1928 had completed college.[6] In 1934 the percentage rose to 48 6.

Educational data on *artists* are difficult to interpret, partly because most art training is carried on in private or semiprivate groups, and there is no uniform system of accrediting for art schools which tends to give formality to educational standards. Data from such sources as "Who's Who in America" suffer from this situation so much that their usefulness is but slight Only the 1934 tabulation includes art schools as a separate category, but the flexibility of meaning of this term is so great that comparability with data on education of other occupational groups is very dubious It is equally questionable if satisfactory comparisons can be made between the various classifications of "Who's Who in America" data. For example, of the 129 artists first listed in "Who's Who in America," 1928–29, and reporting educational data, 25, or 19.4 per cent., reported college degrees,[7] but in 1934 the corresponding figure was 8 5 per cent. In 1899 the percentage was 8,[8] compared with 13 9 for the 1910 data[9] The variation over this period is presumptive evidence of inconsistency of the returns, due either to carelessness in reporting or to inadequacies in the report forms at one or another time Some of the training in art schools of the 1934 list probably was given as college training in 1928, and some of those not reporting education in 1910 probably had the same type of education as those recording art school education in 1934, simply because there was no way of reporting art education in 1910 and no other formal education had been obtained or was considered worth recording. Under these conditions it is impossible to determine trends in education of outstanding American artists from "Who's Who in America" data. We do not know whether art school education or college education has increased for the group or what changes have taken place in the other educational categories of the formal educational background of such people

Data on *musicians* are subject to some of the same difficulties as those for artists. In 1899, 36 per cent of the "Who's Who in America" musicians did not furnish educational data.[10] In 1910, 36.4 per cent of the musicians listed did not record preliminary educational data,[11] and in 1934, 16 6 per cent. reported insufficient educational data for analysis, compared with 31 9 per cent. who reported musical education. Since musical education is not included as a category of the

4 E G Dexter, *The Popular Science Monthly,* 61: 247, 1902.

5 *Ibid*

6 "Who Who's in America," 1930–31, p. 26.

7 *Ibid*

8 Dexter, *op cit*, p. 247.

9 "Who's Who in America," 1910–11, p. xxv.

10 Dexter, *op. cit.*, p. 247.

11 "Who's Who in America," 1910–11, p. xxv.

1899 and 1910 tabulations, strict comparability can not be obtained. However, college training increased and common school training decreased, if we can accept the reports on these items alone. Of the 1899 list, only 6 per cent. were college graduates,[12] compared with 19 4 per cent. in 1910[13] and 21 3 per cent in 1934 We still can not be sure of the accuracy of these data, but it seems probable that the errors involved in reporting these two levels of education are insufficient to cancel the differences.

Information on *actors* is also unsatisfactory. No actor listed in the 1899 directory reported education beyond the secondary school level[14] This is almost certainly an understatement of such education, although the youthful beginnings of outstanding professionals of the stage formerly was as proverbial as the cleavage between this vocation and that of the rest of society In 1934 only 8 7 per cent. of persons prominent in the theatrical and motion picture world reported college degrees, but almost 20 per cent more had attended college. The total for college education was lower for this vocation than for any other occupation except art. Nearly 42 per cent had only a common school education, the highest percentage of any occupation The increased importance of college theatrical groups, however, may be expected to have an effect on the educational status of the theatrical leaders of the future On the other hand, unless the theatrical profession changes sufficiently for persons who have never acted professionally prior to the age of completing education to avoid serious handicaps to their careers, the increase of college-trained theatrical leaders will probably not be great

At the present time no data are available on trends in education of prominent *architects*. The 1934 data did not differentiate this group Of those names first added to "Who's Who in America" in 1928, 82.1 per cent. had attended college, 53.6 per cent being graduates.[15]

Scientific, Medical and Technical Vocations

For *scientific men* the degree of education is even greater on the average than for literary men And this had been true for a long time De Candolle, one of the earliest students of eminent men, but focussing his attention mainly on scientists, mentioned education as one of the chief factors in their production[16] And almost all "starred" American men of science a generation ago were highly educated, generally attending the world's best universities and taking advanced degrees in them[17] In spite of this, there has apparently been a tendency toward higher educational levels for "Who's Who in America" scientists in more recent years At the turn of the century only 55 per cent of the scientific group reported college training,[18] in contrast with figures of 92 9 per cent. for those first listed in 1928,[19] and 89 2 per cent. for all scientists included in the 1934 edition[20]

Evidence on education of eminent *engineers* also shows a definite trend toward increased education In 1899 only 37 per cent. of the engineers listed

[12] Dexter, *op cit*, p 247.

[13] "Who's Who in America," 1910–11, p. xxv.

[14] Dexter, *op. cit.*, p. 247.

[15] "Who's Who in America," 1930–31, p 26.

[16] Alphonse de Candolle, "Histoire des Sciences et des Savants depuis deux Siècles," Second Edition, Geneva Basle, 1885, 410–411

[17] J. M Cattell, "A Further Statistical Study of American Men of Science," *Science*, n s, 32: 643 At this time 92 per cent held baccalaureate degrees and 75 per cent doctorate degrees in philosophy or science Nevertheless, Simon Newcomb and William James, the most eminent American scientists in 1903, had no regular college or university education, Cattell, *Idem*

[18] Dexter, *op cit*, p. 247.

[19] "Who's Who in America," 1930–31, p. 26.

[20] Based on a combination of data for geologists, chemists and other scientists, taken from Table I.

in "Who's Who in America" were college graduates,[21] compared with 72 0 per cent. college attendance and 55 5 per cent college graduation for persons in technical engineering occupations listed in "Who's Who in America" 1910–11.[22] A larger percentage was disclosed by a study of 730 engineers chosen as eminent by virtue of holding office, being a member of a standing committee, or being a representative of one of four leading engineering societies during the years 1915–1919 inclusive The American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Mining and Metallurgical Engineers Of the 730 men, 79 5 per cent had the equivalent of a college diploma, 4 8 per cent. had attended college without graduation, and 15 8 per cent had only secondary school training Highest leadership in the electrical and mining and metallurgical fields was more nearly closed to the person without college training than was highest leadership in the civil and mechanical engineering groups Only about 11 per cent of the former leaders had no more than a secondary education, compared with almost 20 per cent for the latter two groups Of the engineers in this list, 315 were also in "Who's Who in America"[23] And of these 85 4 per cent were college graduates and 5 7 per cent more had attended college without graduation

There has been no further significant change in the education of the engineering group In 1934, as a matter of fact, those with college degrees constituted a smaller proportion of the total than was disclosed in Walters' "Who's Who in America" group The corresponding figure for the engineers first admitted to the list in 1928 was 92 1 per cent[24]

[21] Dexter, *op cit*, p 247.

[22] "Who's Who in America," 1910–11, p xxv.

[23] Raymond Walters, *School and Society*, 13: 322–329, 1921.

[24] "Who's Who in America," 1930–31, p 26

Physicians and surgeons included in the 1934 list reflect the high educational standards of the profession. "Who's Who in America" did not include any medical leader who had not a doctor of medicine degree. This was the only vocational group in the entire list that was 100 per cent college trained In 1899 the record was much poorer. In that year only 42 per cent. reported college graduation,[25] compared with 71 8 per cent college attendance and 54 4 per cent graduation in 1910[26] Data on starred scientists in the field of medicine from the 1903 and 1910 studies of Cattell show a much higher percentage of persons with college degrees than for the medical men in "Who's Who in America," 1910–11. A total of 94 1 per cent of the 238 cases had doctor of medicine degrees,[27] and probably a number of others had attended college, although it must be recognized that holding the M D degree does not signify previous baccalaureate degrees for these various lists. Higher degree of eminence, nevertheless, appears to be associated with higher levels of education in the medical group

Undoubtedly the most powerful factor in the present educational level and in the phenomenal gains registered since 1910 is the prestige and the set of certification standards of the American Medical Association So important for professional success is such certification that few physicians can practice without its full sanction and no person can become nationally prominent in medicine without this sanction As certification has become based on progressively rising educational standards, a doctor's degree from an accredited medical school has in late years become increasingly as prerequisite for professional tolerance as it has even longer been for leadership in the profession. It is not as a medical man that a person without a medical degree can now

[25] Dexter, *op cit*, p 247

[26] "Who's Who in America," 1910–11, p. xxv.

[27] R M Pearce, *Science*, 42 264–278, 1915.

attain the recognition implied by inclusion in "Who's Who in America"

Inventors may also be discussed here, although they are neither scientists nor engineers. Of inventors listed in the 1899 "Who's Who in America" 23 per cent. reported college degrees[28] Later tabulations published in the directory do not, however, report on this group separately from the other miscellaneous vocations A recent study by Winston of American inventors eminent enough for inclusion in the "Dictionary of American Biography" reveals that only 16 7 per cent. held college degrees Although comparisons are of doubtful validity, such data suggest a slight gain in educational status for inventors prior to 1900[29]

Religion, Education and Law

The *clergymen* listed in "Who's Who in America" have consistently reported a high level of education. In 1899, 52 4 per cent had college degrees[30] In 1910 the corresponding figure was 84 0 per cent[31] and in 1934 it was 88 5 per cent This group is closely similar to scientists in the level of education reached and somewhat inferior to medical men in the trend toward advanced levels of education.

Educational leaders surpassed all other groups in level of education in 1899, at which time 72 per cent reported college graduation.[32] The superiority of their educational status is not surprising in view of the fact that the occupational affiliations of most of these leaders was at the level of college and university education For this reason only some other educational level attained would be incomprehensible and require detailed comment. However, comment is required when we note the failure of the average educational status of the group to keep pace with that of the medical men in 1934 Compared with a perfect record for the latter, 1 3 per cent of the educators did not report any college education, and another 1 8 per cent reported college attendance without graduation.[33] Failure to keep pace with medical leaders is mainly due to the more stringent prerequisites for success in the medical profession. It is still possible for a few persons with little formal training to rise to eminence in college and university education in this country just as it always has been But the number who do so is so small that the educational group now is second in educational background only to the medical profession.

Persons prominent in the *legal profession* are slightly inferior in college education to those in religion and education. In 1899 about 46 per cent were college graduates,[34] compared with 53 8 per cent. in 1910[35] In 1934 the corresponding figure was 82 3 per cent The gain reflects the increased importance of college education in the country as a whole The great increase in college graduates is also affected by rising standards of law schools during the period. The requirements for certification to practice law have become somewhat higher, too. The fact remains, however, that some people can rise to eminence in this profession by attending secondary school and short law courses, and by private study, always, to

[28] Dexter, *op cit*, p. 247

[29] Sanford Winston, *American Sociological Review*, 2 846, 1937.

[30] Dexter, *op cit*, p 247.

[31] "Who's Who in America," 1910–11, p xxv

[32] Dexter, *op cit*, p 247 Data on educators and college professors were combined

[33] The figures for first admissions to "Who's Who in America," 1928–29, were lower for college graduation 96 3 per cent ("Who's Who in America," 1930–31, p 26) The same percentage of college attendance (99) was revealed by this source as by a study of 1,552 persons, selected by a method of random sampling from "Who's Who in Education," 1932 (H M. White, "A Study Based on Biographies of Leaders in Education," *M.A Thesis*, University of Kansas, 1934, p 33)

[34] Dexter, *op cit*, p 247

[35] "Who's Who in America," 1910–11, p xxv.

be sure, followed by passing the examinations for certification. In 1910 more lawyers than artists were "self-educated," as many started off with private instruction, as was true of any other group, and far more were educated only in preliminary school. And in 1934 common school education was more prevalent for lawyers than for any other "learned profession" The vocation of law, therefore, exhibits the general trend toward higher education without that education being prerequisite for a successful career In turn, the chances for eminence of the holder of a college degree have apparently increased while those who do not hold degrees are at an increasing disadvantage.

Public Service

Public officials, although lagging behind the learned professions in formal educational background, bear out the same general trend of increasing college education Dexter's study of the 1899 "Who's Who in America" group revealed that only 22 per cent of the United States congressmen and statesmen were college graduates,[36] compared with 59 2 per cent in 1934 An additional 19 per cent had attended college. The total and the graduate figures were much below those for lawyers, in spite of the fact that most of the highest public officials have legal training The discrepancy is to be explained mainly by our political system which makes it possible for persons with a minimum of education but a maximum of political power or prestige to be selected to make and administer the laws of cities, states and the nation.

All *army officers* above the rank of colonel *and navy officers* above the rank of captain are automatically listed in "Who's Who in America" These men exhibit the general educational trend quite as strikingly as any other group, although it might be supposed that the general trend would not have affected them In 1899, 55 per cent. were listed as having education equivalent to that obtained in colleges and universities.[37] This figure placed the military group among the leaders, a position it has maintained. In 1934 the percentage having education approximating college graduation was 95 2 of all those reporting adequate educational data Even when allowance is made for possible differences between the meaning of "college education" of the 1899 study and "equivalent to a college education" in 1934 there certainly has been a rise in percentage with high formal education This group at all times has taken its place with the most highly educated classes, being surpassed in 1934 in percentage of graduates only by medicine, education and chemistry, and in total college education by medicine, education, religion, geology and chemistry

Business Men and Agriculturists

Business and industrial leaders exhibit an entirely different picture from that of most of the groups mentioned previously. They most nearly resemble public officials, journalists and authors. In 1899 only 12 per cent of business men and 18 per cent of financiers were college graduates[38] In 1934 the total college group constituted 67.7 per cent (graduates 49 8 per cent) of the business and industrial leaders listed in "Who's Who in America" This impressive gain has been accompanied by an expansion of accredited business school enrolment as well as by the general increase in college attendance.

Although not strictly comparable to these data, it is interesting to note that the college percentage of graduates among American millionaires reported by Sorokin in 1925 was 54, and thus surpassed the "Who's Who in America"

[36] Dexter, *op cit*, p. 251.

[37] Dexter, *op. cit*, p. 247.

[38] *Ibid.*

figures,[39] as would be expected in view of the assumption that the most eminent persons of an occupational group would have more college education, because college education is an advantage in obtaining prominence.

A study by Taussig and Joslyn of several thousand directors of American corporations in 1928 provides a further basis of comparison with the "Who's Who in America" data. Of the whole group 31 9 per cent. were college graduates, and 13 4 per cent more had attended college, compared with 26 7 per cent who had not continued their education beyond grammar school[40] These figures are between the 1899 and 1934 "Who's Who in America" proportions. More significant, however, are figures on education of the subjects by age groups The percentage of college graduates and those with college education rather consistently decreased as the age of the group increased Of those men 75 years of age and over only 15 0 per cent were college graduates and 11 5 per cent had attended college without graduating The corresponding figures for those from 45 to 49 years of age were 34 1 and 13 5 per cent compared with figures of 42 1 and 23 7 per cent. for those under 30 years of age[41]

No evidence on trends in the education of prominent *agriculturists* is available at this time, although the high status of this group in 1934 (55 3 per cent college graduates) suggests an increase in higher education in recent decades. Collateral evidence is not of much assistance here, although various studies have been made. It has been found, for example, that a large number of "agricultural" leaders, including research workers and teachers in the field, directors of extension, and of experiment stations, editors of farm publications, managers of farm organizations and government officials and farm operators listed in *Rus*, 1925, were almost uniformly college trained. Only 4 1 per cent reported no college education, 88 8 per cent. were graduates of colleges and 7 1 per cent had attended without graduating[42] However, this group is so heterogeneous, and includes so many people who have been included in other occupational groups in "Who's Who in America" data that the two kinds of information are not exactly comparable. The same thing is true of the group of 383 Master Farmers studied in 1930, of whom only 14 3 per cent were college graduates, and only 27 6 per cent had attended more than one year[43] Since the years of study were not far different in these investigations, they appear to show a complete range of inclusion from true farmers (master farmers) to a group consisting of proportionately few actual farmers (leaders from *Rus*) The "Who's Who in America" group were more equally balanced, although actually including fewer farmers than the master farmer study. If this characterization is correct, the master farmer study is the only one that reveals the farm operator's educational status at all accurately. The percentage of college-trained persons in this group is small but still sufficiently large to leave the possibility of a gain in the last generation in the percentage with college education The growth of university extension and of agricultural college enrolments has been so great that it seems likely that nationally recognized farm owners and operators have been and are on the way to higher educational levels

39 P. A. Sorokin, *Social Forces*, 3 637, 1925 Of particular interest is the fact that only 11 7 per cent of millionaires of "poor" financial status at the beginning of their careers had graduated from college, compared with 42.2 per cent. and 80 4 per cent, respectively, for those with "middle" and "rich" status at the beginning of their careers

40 F. W. Taussig and C. S Joslyn, "American Business Leaders," New York, 1932, p. 162

41 *Op cit*, p 164.

42 P. A. Sorokin, C C Zimmerman, *et al*, *Social Forces*, 7. 40, 1928

43 O Hamer, *University of Iowa Studies in Education*, 6, No. 2, 1930, 120

just as are or have been all the other groups concerning which we have direct evidence

By way of summarizing these data on trends a comparison is provided in Table II between the percentages of college graduates by occupations in 1899 and 1934 Occupations which increased in college education at a faster rate than that of the total group, given in the order of their superiority in rate of increase were medicine, technical engineering, business, public office, law, army and navy and religion[44] The margin of superiority for all these but the first was less than 5 percentage points The occupations gaining least in percentage of college graduates were art, theater and motion pictures, and publishing

[44] The percentage for the whole group for 1934 revealed by Table II differs from that of Table I of the former article on education of eminent men *Cf* Smith, *op cit*, p 552 The explanation is that the present table includes persons trained in art and music schools, while the former article eliminates them for purposes of strict comparability of various "Who's Who in America" statistical tabulations

These differences in rate of increase are not as revealing as an index of the percentage gain which the actual gain from 1899 to 1934 represents of the percentage of college graduates in 1899. When this method of comparison is employed the outstanding group is seen to be business leaders, followed in order by musicians, public officials, doctors and technical engineers, all of which groups surpassed the average for the whole list.

Even this measure is not the most satisfactory indication of improvement in educational status, as measured by college graduation, however, because only in occupations of less than 50 per cent college education in 1899 could there have been more than a 100 per cent gain. Some measurement of the ratio of percentage gain to the amount of possible gain is indispensable if we are to have any clear basis for understanding the changes. Column 5 of Table II presents such an index And here it is seen that medicine made the greatest possible gain, 100 per cent, followed closely by education which had lagged in both other

TABLE II

CHANGES IN THE PERCENTAGES OF ENTRIES IN "WHO'S WHO IN AMERICA" REPORTING COLLEGE GRADUATION, 1899–1934

Occupation	Percentage 1899 Col 1[a]	Percentage 1934 Col 2[b]	Amount of gain in percentage points (Col 2 less Col 1) Col 3	Index of percentage gain (Col 3 × 100) / (Col 1) Col. 4	Percentage gain of possible gain (Col 3 × 100) / (100 − Col 1) Col 5
Authorship	27	50 9	23 9	89	33
Journalism	33	48 6	15 6	47	23
Art	8	8 5	5	6	0 6
Music	6	21 3	15 3	255	16
Theater and motion pictures	0	8 7	8 7	∞	9
Science	55	89 0	34 0	62	76
Technical engineering	37	76 9	39 9	108	63
Medicine	42	100 0	58 0	138	100
Religion	53	88 5	35 5	67	76
Education	72	96 9	24 9	35	89
Law	46	82 3	36 3	79	67
Public office	22	59 2	37 2	169	48
Army and Navy	55	91 1	36 1	66	80
Business	12	49 8	37 8	315	43
Total	**37.2**[c]	**72.7**	**35.2**	**95**	**56**

[a] Dexter, *op cit*, p 247 Apparently these percentages are based on all persons in each occupation, while the 1934 data eliminate those reporting no educational information Consequently, Dexter's percentages are probably understatements

[b] Based on "Who's Who in America," 1936–37, pp 2706, 2708

[c] Dexter did not include educational information on all groups, so that this figure is tentative and probably an understatement when compared with the 1934 college-trained group.

measures of improvement, mainly because its original position was so very favorable. The army and navy, science and religion, law and technical engineering made better than average showings, compared with business, music and public office, which showed up so well in percentage gain but achieved less than half of their possible gain The arts made the poorest showing, with art the greatest laggard of all, partly because of the ambiguity of the term "art education," and the inconsistency in the statistical treatment in different analyses

Education and Chances for Prominence by Occupation

The comments made in the last few paragraphs have left to one side the question of the actual contribution of college graduation to potential leaders in these fields of endeavor Statistical errors have been pointed out and the importance of standards and accrediting agencies have been reviewed Now it will be of advantage to consider the contributions of college education through differential chances provided by it for eminence and the precise way in which it aids the potential leader

Evidence that college education is a definite aid to eminence in a field of activity is satisfactory only when there can be no further question of that aid, that is, when other possible interpretations of the facts have been found wanting This rarely is possible to do, because of the inability to discover or create instances in which each condition and all combinations of conditions can be inserted or eliminated from the pattern of eminence causation In the absence of this completely satisfactory method, it is still theoretically possible, however, to consider the relative chances for eminence in each field of endeavor possessed by persons with different sorts of educational background In another place information of this sort, obtained for the whole eminent group, revealed great advantages for the college-trained person [45] Such a method requires knowledge of the educational background of the eminent persons in each field of eminence, and the educational background of the total persons of a comparable age group in the general population in each field represented among the prominent people under consideration. With this information available it would then be possible to compute the ratio of persons in "Who's Who in America" engaged in each field of activity and with a certain educational background to the total living persons of a comparable age group and educational background in the whole country Differentials in the ratios for persons of different educational backgrounds would reveal the advantages and disadvantages of each sort of educational background for eminence

Available information is not sufficient, however, to enable us to make such analyses The educational background of persons engaged in various occupations in the United States is not known and can not at present be accurately inferred, so that none of the fundamental ratios necessary in analysis in terms of chances for eminence can be computed. This statement is true, in spite of a few attempts to state in numerical terms the advantages of college education for eminence in certain fields Clarke states that college-trained literary personages had "several hundred times" as many chances for recognition as those not so trained,[46] but no statistical evidence is given in support of such a conclusion. Dexter made a similar attempt for various occupational groups, and concluded that the chances for eminence of persons with college degrees ranged from about 6 to 1 for medical men to 2 to 1 for lawyers and judges [47] These figures, based

[45] Smith, *op cit*, 557
[46] Clarke, *op cit*, p. 68
[47] Dexter, *op cit*, pp 249–251

on the assumption that the previous education reported by entrants of professional schools is closely comparable to the figure for the corresponding professions in the whole country, are obviously not accurate enough for differentiation among various occupations. Hamer reported that about 5 times as many master farmers had attended high school and about 6 times as many had attended college as Iowa farmers in general[48] This statement also makes the assumption that Iowa data are typical of data for the part of the United States contributing to the group of master farmers, which is obviously of little use for occupational comparisons All that these three statements reveal is that an advantage is enjoyed by the college-trained man in attaining prominence, a fact which is already well known

It is not possible at this time to improve materially on these efforts But it seems likely that the advantage of the college-trained man is much less in some professional than in most of the non-professional vocations. For example, in the field of medicine, although all the "Who's Who in America" group in 1934 were college graduates, the advantage of such persons in chances for eminence over those without college degrees can not be as great as for some vocations, because the prerequisites for medical certification tend to eliminate the non-graduate not only from the eminent list, but even from inclusion in the occupation The same thing is true of the law, engineering and the sciences, and to a certain extent of education and religion

At the other extreme, agriculture greatly favors the college-trained man, because of the overwhelming proportion of farmers without college education, compared with the rather large percentage of the "Who's Who in America" agricultural group with college degrees This remains true, although few of the agriculturists of this list actually operate farms or otherwise engage in farm labor. Business and industry are also in the group which is aided by education, because of the many millions of poorly educated persons engaged in such vocations. Near the extreme agriculturists and business men is also to be found the military group. The rank and file of soldiers and sailors have little education, while those men of highest rank and greatest prominence are predominantly graduates of the four-year government military and naval academies

CONTRIBUTIONS OF EDUCATION TO EMINENCE

From what has been said above and in a former analysis of the contributions of formal education to eminence,[49] it is apparent that the possession of a high degree of formal education is not sufficient to demonstrate that the education contributed to the attainment of the recognition In the first place, it is possible that in each vocation selective factors explain the correlation of education with eminence And in the second place, a high level of formal education may be prerequisite to a career in an occupation, the education contributing little or nothing in itself to ultimate recognition The use of the college degree as a prerequsite for pursuing a vocation is, on the whole, a much-deplored shortcoming of our civilization. In numerous cases societal pressure is such that the degree, rather than the techniques and education, is the focus of attention, and in not a few instances it is necessary for the student to consider carefully whether the formal aspects of the advanced degree will not cost him more dearly than the worth of the degree will be in obtaining a position where his interests in teaching or creative writing or theatrical studies may then be followed. The confusion arising from the factors of selection and the action of

[48] Hamer, *op cit*, p 66

[49] Smith, *op cit*, pp 558–560

education as a prerequisite, together with the other difficulties of determining the extent of the dependence of variables, literally makes it impossible to conclude that a person in a vocation with almost universal formal education at a certain level is aided more by formal education than the one in a vocation few of whose members have attained that level.

The difficulties of determining the reason for the correlation of high degree of formal education and eminence that exist for eminent men as an undifferentiated population group are multiplied in proportion to the differentiation of vocations The best that can be done now is to make a few suggestions concerning the reasons for the formal education of the sort reported for each occupation in Table I, recognizing always that the most superior persons yet may make the greatest achievements without specific degrees of formal education, although they may require the highest order of genius in order to make such achievements. For this purpose the existence of formal college education for each vocation may be considered, as well as the precise contribution of that education in terms of opportunity to obtain technical knowledge, general prestige, entrée to the circle of leaders in the field, shortening of time required to learn the techniques of the vocation and companionship with other students having the same vocational interests.

In the various artistic fields the most outstanding implication of existing knowledge is the relatively small opportunity that existed for college training in such vocations a generation ago, at which time, on the average, the current eminent personages were preparing for their careers Authorship is different from the other artistic vocations in this respect, because it is the one most definitely aided by college education The special techniques of these vocations, even of authorship, however, generally had to be obtained apart from and in addition to the college study. And where facilities for training in these techniques were available in the college it was often true that entrée to actual leaders in the various fields was not provided, and the general prestige of the institution in an artistic direction was of little value. It is highly unlikely that the techniques of art were as well taught in any of the colleges and universities a generation ago as outside of them in special schools or private studios Consequently, it is reasonable to conclude that the small percentage of college education for the artistic groups represents comparative lack of advantage or actual handicaps of such education at the time to careers in such fields. Even such items as companionship with other students and the existence of leisure time for study, which all group education supposedly provides, were rarely advantageous to persons of artistic interests who were seeking baccalaureate degrees, since ordinary student interests are not in artistic achievement, and leisure undirected toward one's major interests may not only weaken them somewhat but may even establish strong habits of use of leisure time in ways that contribute nothing to achievement or recognition, but are nonetheless with difficulty broken It is even probable that the college degree a generation ago has to its discredit the prevention of development of considerably more potential leaders along artistic lines than it actually aided

The scientific and technical vocations and the professions of religion, education and law have been most clearly aided by the institutions of higher education To be sure, part of the correlation of success in these vocations with college training is due to the fact that the degree is practically prerequisite to success, but the system of higher education is particularly useful to persons in these fields Universities, throughout the centuries of their history, have been devoted mainly toward

preparation for such occupations. They have established favorable connections with the non-university worlds of these vocations. They have such prestige that the most able persons in these fields often are attracted to their faculties. Where there is such a close contact between the university and non-university worlds the technical side of university education is strengthened and its usefulness to the student is correspondingly enhanced Contact with leaders in each vocation is provided by the foremost educational institutions, and the student's general prestige is likewise increased To these advantages may be added the undoubted advantages of shortening the length of time required to learn the techniques of the vocation and companionship with select persons engaged in studying the same problems.

The vocations of public service, and business and industry, including journalism and agriculture, more nearly resemble the artistic vocations than the professions in the contribution made to them by formal education. College training is not even yet prerequisite to success in any of these activities Colleges, at the time the present national leaders in these fields were completing their education, were not organized to provide well-rounded technical training in government service, or in most business and industry. But the system of military education was as highly organized as any of the professions, even to the point of establishing graduation from the United States Military Academy and the United States Naval Academy as a virtual prerequisite for highest recognition in these vocations. Not only have these practical vocations of government, industry and business lagged in the development of transmissible techniques, but colleges and universities are able to give but little general prestige to their students entering these fields. Similarly, the educational institutions as a rule are unable to attract business and political leaders to their faculties so as to provide contact for their students to the leaders of these fields. The so-called democratic political and economic system is largely responsible for the lack of articulation of the educational system with the political and economic system A man's political contacts in this country exist only so long as he is active in politics and has political influence. Professional educators have been suspicious of political figures and political leaders generally despise or deprecate the educator, with the result that only in rare and notable instances is the gap bridged However, the development of a permanent career class trained in government and the increased use of academic experts by all political groups indicate that the institutions of government and education will eventually be brought into synchronization in the United States, and not only by means of the government entirely absorbing the activities of the university faculty members for months or years during which the university claims are merely formal, and after which the political contributions and contacts of the faculty member no longer continue

University colleges of business, like colleges of fine arts, are rather recent in development and affect the "Who's Who in America" data but slightly. The percentage of college graduates in business and industry, revealed by the present analysis as comparable to that of authorship, like it, is explained more by incidental factors than by direct contribution of education to eminence. Younger representatives of wealthy families who enter business and industry are usually college trained And of the other leaders in business and industry many have attained prominence because of ability and industry rather than as a result of the college training. If these groups could be eliminated from the statistics reported above, the resulting contribution of col-

lege education to business leadership would probably be only slightly more than that of the artistic vocations.

In summary, it may be pointed out that the percentages of recognized persons without formal education in the various vocational groups may also be thought of as an indication of the possibility for eminence in each vocation even when the person has no education. Only in medicine was it true in 1934 that every nationally recognized person reported college graduation. Prior to 1934, under the most favorable conditions, closely paralleling in advantages those of formal education, Americans might have obtained national recognition in every field of eminence but medicine under private tuition Such an accomplishment has become increasingly difficult in recent generations, but until the present time has not been impossible So long as the various advantages deriving from formal education can be obtained in any other way formal education is not absolutely necessary. Only in medicine, and in that vocation only because of the high standards and firmness of control by the accrediting agencies, is it impossible to attain the highest recognition without formal education of high collegiate level.

But consideration makes us realize that if the recent trends continue the difficulties of recognition without a high level of formal education will increase in all fields in the future, and that in several of them college graduation may eventually become prerequisite for leadership. It is obvious, then, that considerable emphasis should be placed on the advantages of college education for eminence in most fields, notwithstanding the arguments of those who explain the correlation of college education and eminence on the principle of selection rather than the contributions of education [50] Somewhere between the extreme claims of the educator and the selectionist lies the true explanation of the correlation, which explanation experience teaches us is more complex than simple and more influenced by the cultural situation and by processes of interaction between persons who achieve and those who evaluate their achievements than is usually realized

[50] This point of view is discussed by P A. Sorokin in "Contemporary Sociological Theories," New York, 1928, Chapter V, and "Social Mobility," New York, 1927, p 187 *ff*.

THE CLAIM OF THE SOCIAL SCIENCES

We are living in a world that threatens to brush aside everything that intelligence stands for. Two great wars and the prospect of more, over half the population of the earth caught in this maelstrom of destruction, ten years of depression with millions everywhere still without employment, confusion over issues and values that leaves men frustrated and uncertain—it is little wonder that the temptation is to forsake reason and resort to force

One of the difficulties is that force seems to be such an easy answer It appears to cut through the complexity and confusion without the necessity of the severe intellectual effort and discipline involved in creating any effective alternative The real tragedy is not that so many men in the world believe in force as a method of social organization as that so many who reject force as an ideal surrender to it in practice because there seems to be nothing else to do

But force in the end always defeats itself In the long run it solves nothing and answers nothing It brings us no step nearer the prospect of the "great society" which science and culture have revealed If the world of the future is a more promising habitation for mankind it will be only as a result of the persistent application not of force but of intelligence against the things that now thwart our hopes —*Raymond B Fosdick, President of the Rockefeller Foundation, from "A Review for 1939"*

BOOKS ON SCIENCE FOR LAYMEN

SAMPLES OF SCIENCE[1]

THE intellect of a nation is stratified At the top we find the university professors and leaders in law, science, business and politics; lower down a layer of college graduates who have had the benefit of a liberal education; still lower a thicker layer of intelligent but inadequately educated office, factory and farm workers, at the very bottom a dense magma of humanity which is more emotional than intelligent, more interested in being entertained than informed Magazine and newspaper publishers hew out circulations in each stratum and in the process make discoveries about human interests When the tabloid was invented during the World War for the sole purpose of enabling a Chicago publisher to rid himself of excess profits it was supposed that what was still called "yellow journalism" had reached rock-bottom and that below it there was unexploitable mental incompetence The tabloid in question proved that in the depths there is still something that can read and write and respond to the raw facts of murder and gossip and especially to situations that are technically known as "he and she" news stories Is this the pre-Cambrian rock-bottom of humanity? It seems not The psychologists have plumbed the vast radio audience and found that it must be appealed to by devices utterly different from those resorted to even by tabloid journalists who rarely use words of more than three syllables

All this is of importance in considering "Excursions in Science" because the chapters of which it is composed are radio talks which should be judged in the light of these psychological revelations. It is very plain that the authors of the talks were utterly unaware of the different techniques that must be invoked to drill down to the lowermost human strata So we have some thirty-seven little essays which, though especially prepared for delivery by radio, were written just as if they were contributions to a newspaper or a magazine Though the authors took the utmost pains to express themselves simply and clearly it is highly questionable whether they were understood by two per cent of their hearers It would be hard even for Sir James Jeans to compete with Charlie McCarthy Thirty-seven writers who are research men and therefore accustomed to analyze problems never troubled to find out how a radio audience should be addressed, but assumed that what is acceptable in the popular press is acceptable from the loudspeaker As radio talks they are not a success As literary products, they are competent thumbnail sketches of the recent work done in surface chemistry (Langmuir), atomic physics (Rochow, Ridenour), lightning (McEachron), thermometry (Elder), fluorescence (Koller, Fonda), solar physics (Hewlett), microchemistry (Liebhafsky), seismology (Smith), probabilities (Benford), electronics (McArthur, Johnson), genetics (Haskins), meteorology (Blodgett).

Most of the authors discuss work in their own research fields and hence with the expected accuracy and authority. There is no attempt at romantic treatment Particularly good is Neil B Reynolds' discussion of science and superstition and his picture of what the scientific method can do in archeology. McEachron has presented an effective account of the recent work done in lightning research. But most of the men are not literary artists. The fingers of a

[1] *Excursions in Science* Edited by Neil B Reynolds and Ellis L Manning xiii + 307 pp $2.50. 1939 Whittlesey House (McGraw-Hill Book Company)

copy editor itch to hack away the redundant "pens" and "pencils" in this passage from Dr Langmuir's otherwise excellent article on "Simple Experiments in Science":

> The pencil is a round one, and the pen has a considerable larger diameter than the pencil If I sit down at a table and place the pencil across the pen I find that I can balance the pencil on the pen by carefully moving the pencil back and forth until the center of gravity comes just over the point at which it touches the pen When I balance the pencil in this way, and then displace it a little by pushing one end down, the pencil, instead of falling off the pen, oscillates back and forth with a definite period of oscillation, like a pendulum

It is good to see that when they put their minds to it professional scientists can write on science in a way that such ordinary mortals as lawyers, corporation presidents and congressmen can understand This reviewer hopes that the editors will repeat their interesting experiment, but that when they do the contributors will soar and tell us more of the implications of research

WALDEMAR KAEMPFFERT

ARE MENTAL DISORDERS INCREASING?[1]

IT is an astonishing fact that ever since the first public mental hospital was established in this country in 1773, states have built further hospitals and additions thereto in a rather hit-or-miss manner, conscious only of the fact that more demands for beds were being made, while at the same time no really informative statistics were being collected as a guide Any business which attempted to run on a similar inspirational basis would long since have gone into bankruptcy!

It remained for the genius of Dr George Milton Kline, Commissioner of Mental Diseases for Massachusetts from 1916 until his untimely death in 1933, and a giant among hospital administrators, to interest the Rockefeller Foundation in subsidizing a thorough-going study of the epidemiological aspects of mental disorder. This work, carried on since 1928 under the supervision of Dr. Dayton, a thoroughly experienced psychiatrist and an outstanding statistician, is now bearing fruit in the form of this volume, a study of 89,190 admissions to the mental hospitals of Massachusetts during the period 1917–1933 Here, for the first time, some facts are presented which had only been guessed before, and other facts which completely refute long-cherished notions During the administration of Dr Kline (the period covered by these statistics) Massachusetts had an excellent state hospital system, reasonably adequate in capacity, a public which had confidence in the institutions and laws which facilitated admission to the hospitals with a minimum of formality There were, in short, no artificial barriers to color the statistics such as exist in some states (such as rigid commitment laws, serious overcrowding, holding of mental patients in jail, etc)

The volume is so tightly packed with information that it is difficult to give an abstract In general, it may be said that through the use of modern statistical devices (and the necessary aid of mechanical sorting) such factors as age, nativity, marital status, use of alcohol and diagnosis are studied year by year and with relation to each other Such a thorough study of so large a number can not and does not fail to yield information which is of the highest significance and validity

Dayton shows that the so-called increase in average length of life is largely due to the decrease in infant mortality and in various preventable diseases, whereas the expectation of life for a person over fifty is actually decreasing. Similarly, the admission rates for persons under 40 are falling, whereas those

[1] *New Facts on Mental Disorders* By Neil A. Dayton. xxxiv + 486 pp. $4 50 C C Thomas Publishing Company.

for persons over 40 have shown a decided trend upward in the 16-year period. This is generally true for readmissions as well as for first admissions. Indeed, the age incidence of mental disease follows the death rates surprisingly closely Taking the 10–19-year group as unity for first admissions (per 100,000), we find the (male) 30–39-year rate to be 4 6, the 60–69 to be 7 2, and the 80–89 to be 19 9 (females slightly lower)! In other words, far from being an affliction of early life, mental disorder is essentially a disease of old age Furthermore, men are shown to wear out faster; the rates throughout life are higher for men than women The fact that mental disorders are decreasing below the age of 40 is corroborative of the belief that the child guidance movement, in which Massachusetts was a pioneer, is showing its preventive effects on the development of mental disease.

As for nativity, the highest admission rates are found in the foreign-born, the next lower in the native-born of foreign parentage, the next in the native-born of mixed parentage, and the lowest in the native-born of native parentage, but—the increase in the rates of the last-named group has gone up so rapidly in 16 years while the others remain almost stationary that the tendency seems to be toward an almost uniform rate

Some evidence for the protective value of marriage (especially for men) is adduced by a study of the figures. The lowest rates of incidence are found among the married, with an ascent in order through the widowed and the single to the divorced Interestingly, the incidence for single men is 60 per cent higher than for single women, and for widowed and divorced men is 35 to 40 per cent higher than for women of the same marital status. In other words, the breaking up of the home is bad for either sex, but works greater hardship on the male

The findings as to use of alcohol appear to indicate that since 1924 (the high point), despite unemployment and depression, there has been a decrease in alcoholism among persons admitted to mental hospitals Prohibition seems to have had a more lasting effect on females, the group who needed it the least (34 per cent of the males as against 74 per cent of the females were reported as abstinent)

The most significant chapter, perhaps, is the final one, entitled "Are Mental Disorders Increasing?" The author proves a fact which has been heretofore almost entirely overlooked, namely, that the increase in mental hospital population, about which there has been so much popular clamor, is due only in small measure (about one sixth) to the increase in admissions The fact is that the increase is due to the piling-up of long-residence patients, together with the fact that the average stay in hospital was found by the author to have increased from 8 9 years in 1929 to 9.7 years in 1937 Some idea of the length of residence of some types of cases may be gathered from the fact that at the end of 1937 it was found that one third of the patients in the Massachusetts state hospitals had been in residence 10 years or more, and 14 per cent 20 years or more Indeed, nearly 0 7 per cent had been patients for over 40 years!

The author concludes the chapter with the pregnant statement:

> Here we have two implications (1) that society has been unable to absorb recovered patients ready for discharge to as great an extent in recent years as in past years and (2), that changes are taking place in the recoverability of existing mental disorders, which necessitate a longer period of hospital residence for purposes of treatment Either question offers a major challenge to the psychiatrist, to the administrator and to society as a whole

The volume is probably the most significant contribution to our knowledge of the statistics of mental disorder ever

published It is to be hoped that the research of Dr Dayton will be continued, to furnish further fruitful volumes In the meantime, psychiatrists, legislators, sociologists and thinking citizens in general are greatly in the debt of Dr Dayton for having thrown much light into places hitherto dark and puzzling

WINFRED OVERHOLSER

SAINT ELIZABETHS HOSPITAL,
WASHINGTON, D. C.

PRESENT AND FUTURE OF TELEVISION[1]

"THE Victory of Television" presents an interesting account of present accomplishments and future possibilities of television, written for the layman who is interested in what this means of communication has to offer rather than in the principles of picture transmission The first two chapters give a brief, very elementary summary of the history and operation of a modern television system There follows a description of the technique used in the studio production of visual programs, with a mention of the problems of obtaining suitable lighting, sound and scenery effects A number of ingenious expedients that have been adopted to produce the required illusions are recounted After discussing at some length the wide range of subjects suitable for television broadcasting, including educational and cultural material as well as features intended solely for entertainment, another, very important phase of the subject is broached, that is, the economic aspects of program production, broadcast maintenance and interlinking networks The book concludes with a discussion of the unlimited future possibilities of television

V K ZWORYKIN

[1] *The Victory of Television* By Philip Kerby Illustrated. x + 120 pp. $1 00 1939 Harper and Brothers.

SHELL COLLECTOR'S HANDBOOK

THIS handy little book provides a very useful means of identifying shells collected by the average amateur naturalist The scope of the book is the coast line from Labrador to Cape Hatteras, and while it has been obviously impossible to include all species, a fairly representative selection has been made and practically all the forms most commonly found by the shell collector have been mentioned

The book is divided into five parts: first, the marine pelecypods or clams in which 48 species are described and illustrated, second, the marine gastropods or snails, including 44 species; third, the fresh-water pelecypods with 24 species, then the fresh-water gastropods with 20 species, and finally the terrestrial gastropods or land snails with 32 species

Although the marine species included in the book range from Labrador to Cape Hatteras, the reviewer has found the book to be somewhat more useful in determining the shells of the beaches from New Jersey northward than those of the more southern portion of the area covered.

The sections on the land and fresh-water shells should be particularly welcome at the present time While there are a number of different books available to the amateur naturalist that describe and illustrate the marine shells of different sections of the coast, there has been very little available in non-technical terms on the land and fresh-water mollusks

There are illustrations of each species described, the majority being adequate for identification purposes There is also an introduction a glossary and an index.

HORACE G RICHARDS

[1] *What Shell Is That?* By Percy A Morris. 168 figures x + 198 pp $2 25 1939 D. Appleton Century Company

THE PROGRESS OF SCIENCE

THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE National Academy of Sciences held its seventy-seventh annual meeting on April 22, 23 and 24 at its home in Washington, D. C. At this time of the year the Japanese cherry trees and other plants and shrubs are in blossom and bespeak the passing of winter. Washington is crowded with visitors, eager for a foretaste of spring and its promise of relief from the routine of winter. One hundred and forty members of the academy attended the meetings and thirty-three presented papers at the scientific sessions; fifteen other papers were given by men introduced by members. The distribution of these papers among the sciences was: mathematics, 4; mathematical physics, 2; astrophysics, 2; physics, 7; chemistry, 5; physical chemistry, 3; geology, 2; biophysics, 6; biochemistry, 2, pathology, 2, biology, 3; bacteriology, 2; botany, 6; anthropology, 1; psychology, 1

The Tuesday afternoon session was set aside, as an experiment, for the presentation of six invited papers from different fields of science on topics of interest to the specialist and to the layman. Dr G D Birkhoff, of Harvard University, spoke on the "Principle of Sufficient Reason," and showed that this principle is intimately connected with what might be termed the Theory of Ambiguity and with the associated mathematical Theory of Groups which has contributed much to the understanding and solution of problems in the physical sciences. Its fruitful application to biological and social theory will probably be made as knowledge in these highly complex fields of thought develops —Dr K. K. Darrow, of the Bell Telephone Laboratories, described recent discoveries in the field of nuclear fission due to the entry of a neutron into a massive atom-nucleus, thus producing an internal explosion in which the nucleus is divided into two fragments and an enormous amount of energy is released. Many radioactive bodies are formed, and fresh neutrons are emitted in great quantities, possibly adequate to convert the process, once initiated, into a self-perpetuating one under realizable conditions —Dr W H Bucher, of the University of Cincinnati, discussed the origin of submarine valleys on the continental slopes of the North Atlantic and suggested that they owe their origin to erosion produced by deep-seated waves of great length set up by landslides and crustal movements accompanying earthquakes or submarine volcanic outbursts. Impinging on the continental shelf, this type of wave motion persists for many hours Its energy greatly exceeds that of tidal-wave motion and appears to be adequate to accomplish the observed erosion along the margins of the continental shelf —Dr D R Hoagland, of the University of California at Berkeley, referred to the importance of minute quantities of certain chemical elements, such as boron, copper, zinc, manganese and molybdenum in the growth and metabolism of higher plants In larger amounts the same metals may have a toxic effect on plant growth; but their presence in extremely small percentages is necessary for both plant and animal growth.—Dr. Roger Adams, of the University of Illinois, discussed the "Chemistry of Marihuana," and described experiments made to isolate the active physiological agent in the resin exuded by the female hemp plant at the time of flowering. By proper extraction of the resin a high-boiling viscous product known as "red oil" is obtained which carries an active principle. Two inert substances, cannabinol and cannabidiol, have thus far been

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DR R T CHAMBERLIN
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DR WILLIAM J ROBBINS
DIRECTOR, NEW YORK BOTANICAL GARDEN

DR LOUIS F FIESER
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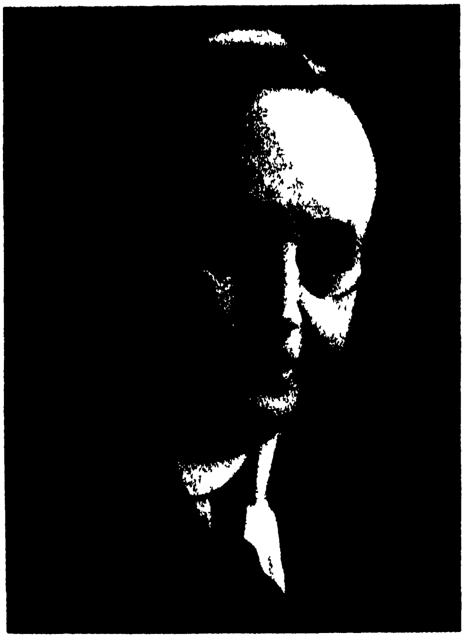
ASSOCIATE PROFESSOR OF PSYCHOLOGY, PRINCETON UNIVERSITY



DR S WALTER RANSON
PROFESSOR OF NEUROLOGY, NORTHWESTERN UNIVERSITY.

obtained, but the active principle has not yet been isolated and identified —Dr W G MacCallum of Johns Hopkins University spoke on viruses and their part in disease He emphasized their extreme minuteness, their dependence upon living cells for growth; their action in producing disease and predisposing to secondary bacterial infection, their action in producing antibodies and lifelong immunity, and their fairly specific relation to certain hosts He referred to recent experiments on the crystallization of a certain virus as a nucleo-protein, perhaps with ferment activity, and alluded to the difficulty of ascertaining the borderline between inanimate and living in virus problems

The Monday evening public lecture was given by Dr E O Lawrence, of the University of California at Berkeley, on the subject "Bombarding Atoms" For this purpose the cyclotron was devised by Dr Lawrence, who traced its development during the past decade to the present apparatus capable of projecting neutrons at voltages in excess of 15 million volts He referred also to the huge cyclotron now in process of construction, with which 100 million volts will be obtained He illustrated by simple experiments some of the results obtained by use of the cyclotron which is the most important tool now available to students of nuclear physics and possibly also to workers in biophysics and biochemistry Dr Alfred Loomis served as test object in one of these experiments

The average attendance at the sessions in the auditorium was 300 and in the lecture room 200, at the evening lecture 575 persons were present

On Monday afternoon seventy academy members and guests visited the Library of Congress and its new annex building The librarian, Dr Archibald MacLeish, welcomed the group and referred briefly to the purposes and functions of the library as an aid to scientists and scholars The visitors were shown

the new facilities in the annex for making photostat and microfilm copies of books and newspapers, for printing labels, cards and pamphlets, and for indexing and cataloguing the immense collections of books at the library The visit was extremely interesting and was appreciated by the visitors

At the annual dinner on April 23, three medals were presented The Agassiz Medal for Oceanography was awarded to Frank Rattray Lillie, past president of the Woods Hole Oceanographic Institution, "for his important contributions to the science of oceanography through his promotion of the plan, adopted by the Academy, by which the United States should take part in a world-wide program in oceanography" The presentation address was made by Dr E G Conklin, a member of the committee that recommended the award

The Public Welfare Medal, from the Marcellus Hartley Fund, was awarded to John Edgar Hoover, director of the Federal Bureau of Investigation, Washington, D C, "for his application of scientific methods to the problem of crime prevention" The presentation address was made by Dr Max Mason, a member of the committee that recommended the award

The Charles Doolittle Walcott Medal and Honorarium were awarded to Dr A H Westergaard, of the Sveriges Geologiska Undersokning, Stockholm, Sweden, "for his eminent researches on the stratigraphy and paleontology of the Cambrian formations of Sweden" The presentation address was made by Dr C G Abbot, a member of the Board of Trustees that recommended the award The medal was received, on behalf of Dr Westergaard, by the Minister of Sweden, the Honorable W Bostrom, for transmission through diplomatic channels

At its business meeting on Wednesday, April 24, the academy elected the following officers and members

Foreign Secretary

L J Henderson, Lawrence professor of chemistry, Harvard University

Treasurer

J C Hunsaker, head of the department of mechanical engineering, Massachusetts Institute of Technology

New Members of the Council

S A Mitchell, professor of astronomy and director of McCormick Observatory, University of Virginia

W Mansfield Clark, De Lamar professor of physiological chemistry of the School of Medicine, Johns Hopkins University

DR JAMES B MURPHY
MEMBER OF THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

Oswald Veblen, professor of mathematics, Institute for Advanced Study, Princeton

New Foreign Associates of the Academy

Sir Henry Dale, National Institute for Medical Research, Hampstead, England

James P Hill professor emeritus of embryology, University of London

Bernardo A Houssay, facultad de medicina, Instituto de Fisiologia, Buenos Aires, Argentina

Giuseppe Levi, visiting professor, Institute of Pathology, University of Liege, Belgium

New Members of the Academy

Rollin Thomas Chamberlin, professor of geology, University of Chicago

Carl Ferdinand Cori, professor of pharmacology, School of Medicine, Washington University, St Louis
George Washington Corner, professor of anatomy, Strong Memorial Hospital, University of Rochester
Louis Frederick Fieser, professor of chemistry, Harvard University
Wendell Mitchell Latimer, professor of chemistry, University of California at Berkeley
Karl Friedeirch Meyer, professor of bacteriology and director of the Hooper Foundation, University of California
James Baumgardner Murphy, member of the Rockefeller Institute for Medical Research
Isidor Isaac Rabi, professor of physics, Columbia University
Stephen Walter Ranson, professor of neurology and director of the Neurological Institute, Northwestern University
William Jacob Robbins, director, New York Botanical Garden
Richard Edwin Shope, Rockefeller Institute for Medical Research, Princeton, N J
William Hay Taliaferro, professor of parasitology, University of Chicago
Stephen Timoshenko, professor of engineering mechanics, Stanford University
Ernest Glen Wever, associate professor of psychology, Princeton University.
Claus Hugo Hermann Weyl, professor of mathematics, Institute for Advanced Study, Princeton

The present membership of the academy is 314 with a membership limit of 350, the number of foreign associates is 43 with a limit of 50

The autumn meeting will be held this year late in October at the University of Pennsylvania, Philadelphia

F E Wright,
Home Secretary

THE AMERICAN ASSOCIATION MEETS IN SEATTLE

"Oregon Game Trails," written by Francis Parkman nearly a century ago, is the classic story of an adventurous journey from the Missouri River to the far Northwest This year, from June 17 to June 22, many members of the American Association for the Advancement of Science will assemble for a great scientific meeting in Seattle, Washington, much farther to the northwest than the end of Parkman's famous trails They will not require months to traverse the plains, pass through the mountains and cross the arid regions By railroad from Chicago on luxurious air-conditioned trains, in which they may read or recline at ease, it will take them only three days Or, they can leave New York or Washington by sleeper airplane in the late afternoon and arrive at Seattle between nine and ten o'clock the next morning

Parkman's long journey was for the purpose of the adventures to be experienced in exploring the unknown, the scientists will visit Seattle for precisely the same reason Parkman looked on vast areas that had never been seen by the eyes of white men, the scientists will be looking into many and more marvelous regions of which men never even dreamed before our day Parkman had to depend upon his unaided senses, scientists look into the heavens through giant telescopes, into the essential cells of living organisms with microscopes, into the structure of matter itself with the cyclotron, which will be explained at the meeting by its inventor, Dr Ernest O Lawrence Truly, the adventures of science are the most interesting, important and beneficial that men ever have experienced

It may well be inquired why scientists should go to Seattle for their meeting Although it is a great city, delightfully located amid mountains and on an arm of the sea and the seat of an important university, it is far from the great populous areas of our country The meeting of the association in Seattle is, in part, an expression of the altruism of science It makes possible a celebration of the achievements in science in a region that

THE SAN JUAN ISLANDS IN PUGET SOUND WITH THE DECEPTION PASS BRIDGE IN THE FOREGROUND AND THE OLYMPIC PENINSULA IN THE BACKGROUND

not many decades ago was on the very frontier of civilization. It is a tribute to the rapid progress that has been made in education and culture even while a wilderness was being transformed into the home of an organized and stable society.

Not all the scientists who will attend the meeting in Seattle will be from the Middle West and the East; indeed, a large majority of them will be from the Pacific Coast and the Mountain States. Nor will their numbers be small, for about 2,600 of the more than 21,000 members of the American Association for the Advancement of Science are residents of the western states. In fact, they are so numerous that they have organized the Pacific Division of the association, which holds its own meetings. The joint meeting at Seattle is the one hundred and sixth meeting of the association and the twenty-fourth meeting of the Pacific Division.

At Seattle twenty-nine other societies will meet with the association. Together they will cover many fields of science—the physical sciences, the biological sciences, psychology and education, anthropology, the medical sciences, agriculture. When Parkman made his famous journey, science consisted of natural philosophy and natural history. Now 171 separate scientific societies and organizations are affiliated with the association. They pay no dues and assume no obligations except to meet with the association when their officers think such joint meetings would advance the interests they were organized to promote. The underlying purpose of all of them is to advance science and civilization.

F. R. MOULTON

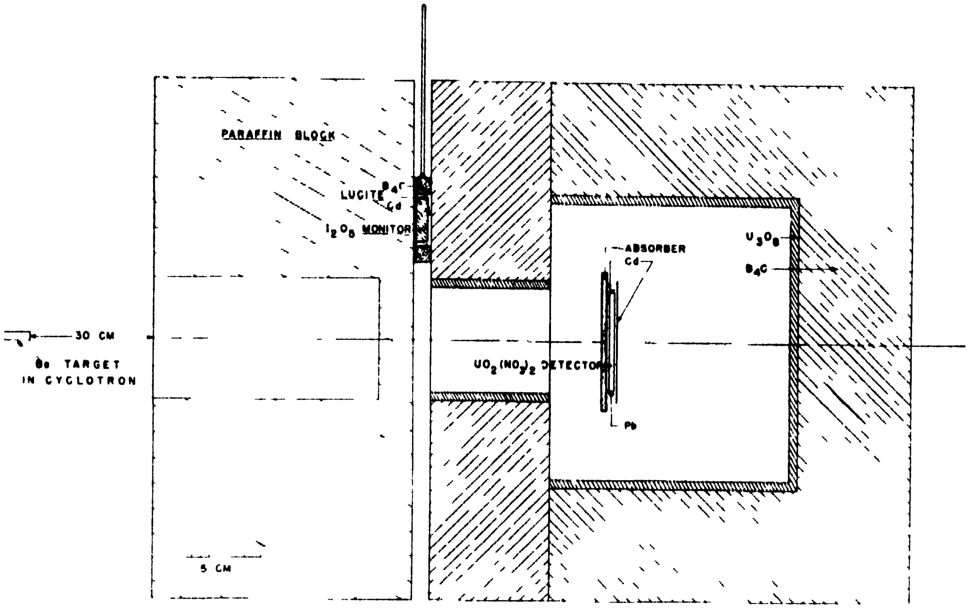
PROGRESS IN HARNESSING POWER FROM URANIUM

THE problem of how to harness the energy which is released in nuclear reactions has interested scientists for many years. In contrast to chemical reaction, upon which we rely for the greater part of our energy supply, the quantity of material which could be made to undergo a *nuclear* reaction has always been extremely small. The problem took a new turn when last year it was discovered that neutrons could be made to split the uranium nucleus with the release of an enormous amount of energy, for soon after this discovery it was found that the splitting of uranium was accompanied by the emission of secondary neutrons. It became apparent that if, in turn, these secondary neutrons could be made to split other uranium nuclei, the reaction might become self-propagating (chain-reaction) and large quantities of uranium be made to release energy. When a uranium nucleus is split it releases 200,000,000 electron volts, the largest conversion of mass into energy that has yet been produced by terrestrial means; this is to be compared with the energy release of 5 electron volts when a molecule of T N T explodes. However, to bring about a chain reaction it is important that not too many neutrons be lost in an unproductive manner before they have a chance to split uranium. Recent research at Columbia University has thrown light on the way neutrons might be wastefully lost.

COLUMBIA UNIVERSITY CYCLOTRON
SHOWING THE EXPERIMENTAL ARRANGEMENT FOR STUDYING THE CAPTURE OF NEUTRONS BY URANIUM

Uranium is split most effectively by slowly moving neutrons; on the other hand, the secondary neutrons which are produced are fairly energetic and must be slowed down before they become effective for splitting. Neutrons may be slowed down by having them collide with some light element like hydrogen. Visualize, therefore, a large mass of a suitable mixture of uranium and water, large enough so that only a few neutrons can escape from the mass and not be utilized. Fast neutrons will then collide with the hydrogen of the water and in each collision lose a part of their energy until they are moving slowly enough to be effective in splitting uranium. However, while being slowed down the neutrons may reach an energy at which they are very readily captured in an unproductive way. Instead of splitting the uranium nucleus, neutrons of about 10 electron volts of energy are captured by uranium to form a radioactive isotope of this substance.

This "wasteful" process has now been studied with the aid of the Columbia 80-ton cyclotron used as a source of neutrons. The experiments established not only at what energy and over how wide a range were neutrons absorbed in this way, but also how strong was the absorption in this region. The knowledge gained by these measurements will enable physicists to take steps to obviate this "wasteful" consumption of neutrons.



PLAN FOR STUDY OF THE RESONANCE CAPTURE OF NEUTRONS BY URANIUM

The photograph shows the cyclotron and the experimental arrangement for studying the capture of neutrons by uranium. The neutrons, which instead of splitting the uranium nucleus produce a radioactive isotope, are those having an energy in a narrow band near 10 electron volts. These neutrons are detected by measuring the intensity of the radioactivity which they produce in a thin layer of uranium. They are produced by slowing down in paraffin the neutrons produced in the cyclotron, and can strike the detecting uranium layer through a hole in a thick shield of boron carbide. If a layer of uranium is inserted in the path of the neutrons a decrease in the radioactivity of the detector will be observed, which indicates how strongly these neutrons are absorbed in this unproductive manner. The experimenter is seen inserting the detector in its place behind a uranium absorber. A cylinder of boron carbide is then pushed forward so as to protect the detector from stray neutrons.

HERBERT L. ANDERSON
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IS ATOMIC POWER AT HAND?

Is atomic power at hand? The flood of reports which have swept the country telling of the isolation of the rare isotope of uranium with mass 235, and the possible implications of this discovery for releasing atomic power, make it desirable that some one sit down, take off the gloves, separate fact from fancy and give a fair picture of what is happening in the laboratories in America and Europe. Here are the facts. Fantasy may come later.

1. Over a year ago, when it was first discovered that uranium and thorium atoms could be split by bombardment with neutrons—neutral atomic particles—and made to release a large measure of atomic energy, it was found that

uranium would undergo fission with both "fast" neutrons of high energies and with "slow" neutrons of low energy

Based on this experimental discovery Professor Niels Bohr, Danish Nobelist, then at the Institute for Advanced Study at Princeton, N J, and Dr John A Wheeler, of Princeton University, suggested that the fast- and slow-neutron splitting of uranium might be due to the presence of two uranium isotopes The rarer kind of uranium, having mass 235, they suggested, would be split by the very weakly energetic "slow" neutrons Only "fast" neutrons of high energy, they postulated, would be successful in splitting the common form of uranium with mass 238

2 The occasion for the recent spectacular newspaper retelling of the story of uranium fission, which has been followed closely in scientific journals and in the press since January, 1939, was the confirmation of the Bohr-Wheeler hypothesis for uranium 235 by Dr A O Nier, of the University of Minnesota, and Drs E T Booth, J R Dunning and A V Grosse, of Columbia University

3 Dr Nier made possible this confirmation by isolating, with a mass spectrometer, a tiny sample of uranium 235, consisting of only a few millionths of a gram of material Other scientists, including Drs K H Kingdon and H C Pollock, of the Laboratories of the General Electric Company, have been effecting similar concentrations of uranium 235 and uranium 238, its heavy common isotope Professor J W Beams, using a gold-plated centrifuge at the University of Virginia, has been working on the problem and is having the material he has isolated checked in a mass spectrometer to determine its atomic weight At Johns Hopkins University Dr R D Fowler and his colleagues are using a thermal diffusion apparatus to effect the separation of uranium 235 from uranium 238

4. The isolation of the uranium 235 isotope is extremely slow, tedious and costly in time and effort Figures discussed by Drs Kingdon and Pollock reveal that even for the much more abundant uranium isotope of mass 238 it takes three hours of operation to produce one and eight-tenths of a microgram, where a microgram is a millionth of a gram and a gram is less than one four-hundredth of a pound

Simple computation shows that at this rate it will take scientists some 70,000 days (over 191 years) to make a single gram of concentrated uranium 238 and over 400 times as long—over 75,000 years —to make a pound of this material The rare isotope of uranium of mass 235, occurring in only one part in 139 in comparison with uranium 238, would take still longer for its production

5 Preliminary indications, not yet conclusively confirmed in America, point to the presence of a chain reaction in uranium fission with neutrons In January of 1940 this evidence was reported from Paris by the co-Nobelist scientists, Professor F Joliot and his colleague, Dr H von Halban It is the chain reaction which is the key to any useful application of uranium fission as a possible source of atomic energy

So much for the facts about uranium's fission which, unembellished, are seemingly prosaic Much better reading—and the cause of the wide-spread use of the recent story—is the speculation about the future of the possible release of atomic energy from uranium

Taking off from fact into fancy one may cite the following

1 The separation methods for the isolation of uranium 235 are bound to improve, so that while it may take over 75,000 years to concentrate a pound of uranium 235 to-day, it may be done far more quickly in the future.

For one thing, if the ratio of concentration of uranium 235 to uranium 238 is now only 1 to 139, as has recently been reported, the problem is not greatly dif-

ferent from the separation of heavy and light nitrogen isotopes Of all the ways of isotope separation known, the thermal diffusion method seems potentially best adapted to the separation of uranium 235 in quantity If any one can figure out a way to spin one of the thermal diffusion columns in a centrifuge so that the two methods may be combined, then the way may be cleared for a fast and effective separation of the two uranium isotopes and physicists may yet get their wish for a 5-pound sample of uranium 235 to work with

2 It may not be necessary to have pure uranium 235 (U–235) to find practical uses True, the U–235 works best with the weak neutrons, but uranium 238, much more common, splits with fast, high-energy neutron bombardment It may be recalled that the discovery of uranium fission was obtained with uranium oxide—a commonplace chemical compound widely spread throughout the earth

3 The energy liberated from uranium by fission is enormous, and weight for weight it is at least 5,000,000 times as effective as coal

4 If the chain reaction of having one uranium atom split and liberate the neutrons which will split another one nearby, and so on, can be controlled, then a compact power source for military purposes could be achieved despite whatever the cost might be Things which are uneconomical in a peacetime sense become practical for military services if they can perform tasks not possible, or carried out as easily, in any other way No price can be put on such developments that might save the life of a nation that owned the discovery, any more than one can put a price on a surgical operation which saves a man's life

5 Is Germany pressing the utilization of the discovery of uranium fission? The answer is "probably yes," for it has been pointed out since the first announcement of the sensational find that Germany was the home of the original discovery, and that German scientists have had a six months and more start on their research

Technically, this is true, but the great uncertainty of Hahn and Strassmann in Germany during the initial stages of their work probably means that the six months' start has been virtually wasted and that American research, particularly, has caught up and perhaps excelled German research in this field

The drive to find ways of applying the discovery of uranium fission is going on in all nations Americans should realize that the research does not require the special large cyclotrons and other atom smashers which dominate the American scientific scene

The whole virtue of uranium fission, aside from any possible practical application, is that it does not require huge apparatus to set off the fissions and release the energy A little bit of radium mixed in a flask with beryllium and embedded in a block of paraffin is the entire "source" that is required This radium-beryllium mixture emits neutrons that may be used to bombard uranium, the uranium splitting and its own chain reaction does the rest

These five points are the fancy which may or may not come true within our time There are others, like the uranium bomb, which go beyond fancy into the fantastic One would be a fool to say that these possibilities will not happen, when it is less than two years ago that talk of atomic power was relegated to talk of perpetual motion, ancient medieval alchemy and the search for the philosopher's stone

It should be realized by all atomic power zealots, however, that even if the chain reaction in uranium fission were conclusively proved and atomic power were a fact to-day, there would still be enormous engineering problems to be conquered in constructing useful machines that could utilize the atomic power

There are still many unsolved difficulties in uranium fission It is not outside the realm of possibility that there may be some yet unrecognized process in which slow neutrons, striking uranium 235, are captured and are thus not productive of the vital fission phenomenon This process of simple capture has been discovered with uranium 238 It may also exist in uranium 235

Probably the sanest forecast of the future is that uranium atomic power will be so valuable, when and if it comes, that it will be used only for the most special purposes for which it is characteristically adapted and which it can do better than anything else

Still nearer reality as a forecast is the discovery that uranium fission will have its greatest benefits as a ready-at-hand, compact source of neutrons which are highly sought after in medicine and biological experiments and in nuclear physics At present huge and costly atom smashers are necessary to create these neutrons for experiments If the chain reaction can be started and controlled in uranium, every university laboratory could have its own neutron source The benefits to research on understanding the structure of atoms—and hence all matter—would be immeasurably enhanced by this advance

NOTE Newest word from Europe to *Nature* (London, May 9) comes from Stockholm, where Professor Krasny-Ergen reports that the war in Scandinavia has made it necessary for him to stop construction of a thermal diffusion apparatus for the concentration of the rare isotope of uranium of mass 235 which holds the possibility of speeding up, more than 10,000 times, the yield of this isotope Professor Krasny-Ergen calculates yields of 1 3 milligrams of uranium 235 per day from his apparatus This means that with a single thermal diffusion tube he could obtain a gram of uranium 235 in about three years Present production by mass spectrometers in America would require over 33,000 years for the same amount It is entirely possible to run a whole series of thermal diffusion tubes in tandem, or individually, and greatly speed up the yield still further

ROBERT D POTTER

SCIENCE SERVICE

THE MILKY DISEASE vs THE JAPANESE BEETLE

UTILIZATION of biological control for insect pests seizes upon the imagination of layman and scientist alike In the case of the former, there is an element of "let George do it" in his attitude—coupled with a blind confidence in results developed from the reading of over-enthusiastic accounts in non-scientific literature

The scientist, on the other hand, approaches the problem as "a consummation devoutly to be wished " but with a full realization that the use of natural enemies is beset with many "ifs," any one of which may prevent the full measure of success

In the Maryland Japanese beetle program, an attempt is being made to retard the multiplication and spread of the beetle by trapping on a large scale in the heavily infested areas of the state, by spraying trees and shrubbery in towns, the treatment of soil with arsenate of lead on lawns and golf greens, and by the utilization of parasitic insects, nematodes and the milky white disease discovered by the late G F White, of the Bureau of Entomology and Plant Quarantine

In this retardation program, which is a cooperative effort among federal, state, county and municipal governmental agencies aided by commodity and farm organizations and individuals, great progress has been made in the education of the public to do its part in furthering the campaign At the same time, 100,000 traps caught last year over 104 tons of beetles, and with 50,000 more traps this year it is anticipated larger totals will be caught this summer

However, the biotic potential of the

AN ADULT JAPANESE BEETLE.

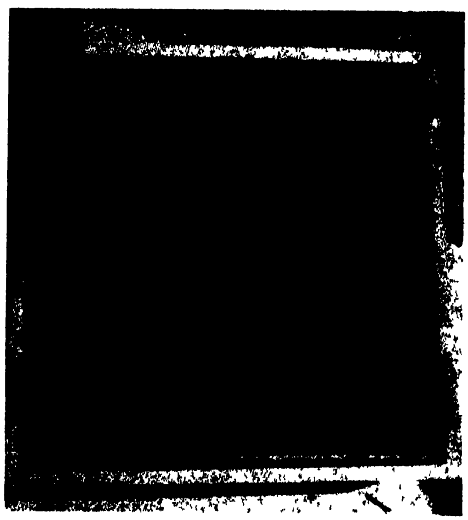
pest is so great that even the catching of such large tonnage can not be expected to complete the subjugation of the insect. But if an effective biological complex can be established there is a good prospect that this imported pest may be reduced to the status of some of our native noxious insects, most of which do only local or sporadic damage that can be checked by the control practices of individuals.

The disease is called the milky white disease because the grubs turn opaque and later die when invaded by the disease. Under experimental conditions, better than 80 per cent of the grubs in treated areas have succumbed to the disease. There is a probability that the disease is responsible for a general reduction of beetles in the older infested areas.

The disease is caused by a spore-forming bacillus that is extremely resistant to the effects of heat, cold, moisture and desiccation, so its chances of survival in the soil are remarkably good. When optimum conditions occur, such as high concentration of grubs and the best conditions of temperature and moisture, it is quite probable that this disease may become an important factor in the reduction of this pest.

The technique of handling this disease is interesting, and, while the present methods are time-consuming, the cost of treatment per acre is so much lower than arsenate of lead grub-proofing of soil that its use is economically practicable. The method is to collect grubs, inject each with the spores, incubate the inoculated grubs, macerate them when they contain the maximum number of spores, mix the spores with talc and spread the talc on the land.

Beginning last November Maryland workers collected a quarter of a million grubs by the first of December. These were stored in wire-bottom trays, 1,000 grubs per tray, in a cold storage room



INCUBATING BOX CONTAINING FIVE HUNDRED GRUBS

at 45° F Unless the grubs are kept dormant by cold they are likely to nip their neighbors, resulting in a big loss in usable grubs In February inoculation of the individual grubs was begun and at the present time all the first quarter of a million grubs have been inoculated

Each grub is given a shot into the dorsal segments with a hypodermic needle loaded with a standardized suspension of spores Each grub gets approximately 2 million spores in about one seventh of a drop of distilled water This injection is made under a binocular microscope with a special micro-syringe actuated by a screw governed by an escapement that regulates the number of turns of the screw It is remarkable that each worker soon learns to inject about 1,500 grubs per day with little injury to the grubs, and achieves a final efficiency up to 70 per cent

After injection each grub is placed in an inch-square compartment in the incubating boxes in soil in which red top and clover seed are mixed Each box contains 500 grubs The boxes are then placed in an incubating room held at a temperature of 85° and a high moisture content The seed germinates, furnishing food for the grubs, and in ten to twelve days the 2 million spores have multiplied to between 2 and 5 billion spores per grub The majority of the grubs remain alive, however, and at the expiration of the incubation period they are removed and those showing milky disease are stored in ice water until a sufficient quantity has been accumulated for the next step This step is the grinding of the grubs with the adhering water into a concentrated suspension of spores Counts in a Levy chamber determine the number of spores per cubic centimeter, and this material is then mixed with precipitated chalk into a dust of known spore concentration per gram and then combined with talc for bulk, so that it may be distributed evenly and in fairly definite spore concentrations on the land that is known to harbor plenty of Japanese beetle grubs The distribution is made at the rate of 2 pounds of dust containing about 75 billion spores per acre

The plan of distribution is to cover as rapidly as possible and as the material is available all the heavily infested areas in the state These areas have been blocked off in square miles in each of which three acres will be treated in the first round. Another one-half million grubs is now being collected which will be used to prepare more spore material for the second round of treatments. The Maryland workers plan to treat approximately 2,000 square miles of heavily infested territory this spring Then spore preparation will be discontinued until this year's grubs have attained sufficient size to be usable About next November the process will be renewed and continued until sufficient dust has been prepared to treat every acre in the state that has a high enough grub count to be suitable for rapid dissemination of the spores

The outlook is good—possibly too good to be true, but in a campaign to reduce the ravages of any serious pest, no method that offers promise can be overlooked Biological methods, if they work satisfactorily, are permanent, relatively cheap and Maryland hopes that the milky white disease may in this large scale experiment prove to be the answer to a serious and perplexing problem.

ERNEST N CORY

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